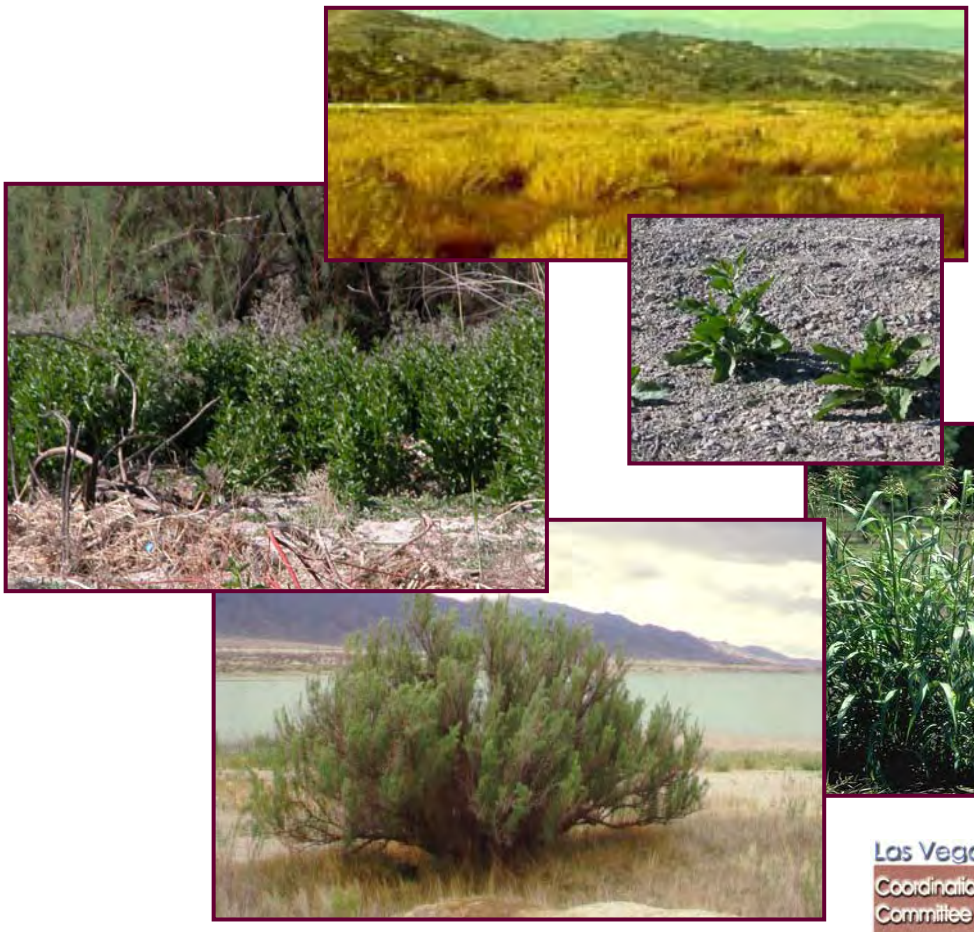
Las Vegas Wash Coordination Committee

Integrated Weed Management Plan for the Lower Las Vegas Wash

Las Vegas Wash Coordination Committee & Las Vegas Wash Weed Partnership

September 19, 2003



www.lvwash.org

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Integrated Weed Management Plan
For the Lower Las Vegas Wash

Las Vegas Wash Weed Partnership

Prepared for:

Las Vegas Wash Coordination Committee, NV

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To promote awareness among the landowners and land managers within the hydrographic basin, facilitate cooperation and collaboration, create a weed control plan, and implement on-the-ground weed management activities in the lower Las Vegas Wash.

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LAS VEGAS WASH WEED PARTNERSHIP MEMBERS

City of Henderson
City of Las Vegas
City of North Las Vegas
Clark County Parks and Community Services
Clark County Public Works – Vector Control
Lake Las Vegas Resort
Nevada Department of Agriculture
Southern Nevada Water Authority
United States Bureau of Reclamation
United States Fish and Wildlife Service
United States National Park Service
United States Department of Agricultural Natural Resources Conservation Service
University of Nevada Cooperative Extension

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ACKNOWLEDGEMENTS

This plan was developed through a collaborative process and is a representation of the thoughts and ideas of the members of the Las Vegas Wash Weed Partnership. We would like to thank each of the Partnership members for their enthusiasm for the project, to Kennedy Jenks Consultants for helping to guide the discussions, and to the National Fish and Wildlife Foundation, Pulling Together Initiative who provided funding for the project. We would like to express our gratitude to the Wash Team and SNWA staff for their countless hours that were spent compiling information, editing and reviewing this document and to the Las Vegas Wash Coordination Committee for their continued support of the weed management program, as part of the stabilization and enhancement effort in the Las Vegas Wash.

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LIST OF ABBREVIATIONS

Best Management Practices	(BMPs)
Clark County Multiple Species Habitat Conservation Plan	(CC MSHCP)
Clark County Parks and Community Services	(CCPCS)
Clark County Public Works – Vector Control	(Vector Control)
Clark County Wetlands Park	(Wetlands Park)
Global Positioning System	(GPS)
Integrated Weed Management	(IWM)
Las Vegas Wash Capital Improvements Program	(LVWCIP)
Las Vegas Wash Comprehensive Adaptive Management Plant	(CAMP)
Las Vegas Wash Coordination Committee	(LVWCC)
Las Vegas Wash Project Coordination Team	(LVWPCT)
Las Vegas Wash Weed Partnership	(Partnership)
Las Vegas Wash	(Wash)
National Division of Forestry	(NDF)
National Fish and Wildlife Foundation	(NFWF)
National Park Service's Exotic Plant Management Team	(NPS EPMT)
National Park Service	(NPS)
Nevada Department of Agriculture	(NDOA)
Nevada Revised Statutes	(NRS)
Nevada State Noxious Weed List	(Nevada Weed List)
Nevada Weed Action Committee	(NWAC)
Southern Nevada Water Authority	(SNWA)
U.S. Army Corps of Engineers	(COE)
Water Quality Citizens Advisory Committee	(WQCAC)

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EXECUTIVE SUMMARY

Introduction

The Las Vegas Wash (Wash) is the primary drainage for the metropolitan Las Vegas Valley, eventually finding its way into the Colorado River watershed system. Pursuant to the recommendations of the Water Quality Citizens Advisory Committee, the Las Vegas Wash Coordination Committee (LVWCC) was formed in 1998 to develop a comprehensive plan for the long-term stabilization and management of the Wash. Consisting of representatives from 28 government agencies, businesses, environmental groups and citizens, the LVWCC formulated the Las Vegas Wash Comprehensive Adaptive Management Plan (CAMP) and designated the Southern Nevada Water Authority (SNWA) as the lead agency for the implementation of the CAMP. Implementation of the plan's 44 recommendations began in 2000.

Invasive plant management has become an integral component of the overall stabilization and enhancement of the Wash. Pursuant to the U.S. Army Corps of Engineers (COE) Section 404 permit, the SNWA is required to mitigate on an acre-per-acre basis of land disturbed during the implementation of the Las Vegas Wash Capital Improvements Program (LVWCIP). Compliance with the Section 404 permit requires that the SNWA maintain an 80 percent survival rate of native species and less than 20 percent cover of invasive plant species. To better facilitate compliance and maximize the effectiveness of the revegetation program in the Wash, the SNWA prompted the formation of the Las Vegas Wash Weed Partnership (Partnership) in 2002, with the assistance of grant funds from the National Fish and Wildlife Foundation (NFWF). The mission of the Partnership is "to promote awareness among the landowners and land managers within the hydrographic basin, facilitate cooperation and collaboration, create a weed control plan, and implement on-the-ground weed management activities in the lower Las Vegas Wash."

Description of Area

The boundary of influence established by the Partnership is the lower Las Vegas Wash, defined as the nine-mile stretch of the Wash from Vegas Valley Drive to Lake Las Vegas, Figure 2. Vegetative analysis has identified 104 plant species comprising nine plant communities. Approximately 40 of these plant species are non-native species. Extensive soil surveys and water quality programs have been conducted to characterize Wash flows. The soils and flows in the Wash tend to be high in electrical conductivity (an indicator of salinity), and therefore require the selection of salt tolerant plants for the revegetation program. Treatment to remove perchlorate ($C1O_4$) is also underway. Ongoing bird, reptile, small mammal and fish surveys have identified more than 300 species of wildlife in the Wash.

There is also an aggressive effort underway to stabilize and control erosion in the Wash. Based on the presence of highly erodible soils and tremendous flow increases through the Wash over the past 25 years, substantial erosion has occurred. The implementation of bank stabilization and weir construction in the Wash provides the opportunity to replace numerous acres of tamarisk

(*Tamarix ramosissima*) and other low quality vegetation with more diverse native vegetation. To date, seven grade control structures have been constructed, with 15 more planned.

Significance of Invasive Plants

Invasive weeds have become a serious problem for land managers throughout the West. The State of Nevada Revised Statue (NRS) 555.0 requires that certain species of invasive weeds must be controlled by law. Responsibility for regulation lies with the Nevada Department of Agriculture (NDOA). A noxious weed list places particular species under regulation jurisdiction, and require landowners (public and private) to manage these plant species. A plant is considered a weed if it is located where it is not wanted and NDOA defines a noxious weed (a legally recognized invasive weed) as "any species of plant which is, or is likely to be, detrimental or destructive and difficult to control or eradicate." Invasive weeds tend to out-compete other native species, and can be destructive to crops, livestock, habitat, and can affect human health and public safety.

Weed Management Priorities

The Partnership's first step was to identify weed management priorities for the Wash. First, the Partnership identified three priority weeds of concern: 1) tall whitetop (*Lepidium latifolium*), 2) giant reed (*Arundo donax*), and 3) tamarisk. There are a number of factors to be considered when prioritizing weeds, including the actual or potential threat, location of infestation, size of infestation, treatment methods, and available resources.

Tall whitetop was identified as the top priority weed because of the tremendous threat it poses downstream in Lake Mead and the Lower Colorado River Basin. Tall whitetop is a particularly aggressive weed that increases erosion of soils, spreads quickly, and is difficult to control. Because the size of the existing infestation in the Wash is still manageable, priority was placed on addressing this weed first.

Giant reed was identified as the second priority species because the infestation is small enough that it can be easily addressed in conjunction with treatment of tall whitetop before it becomes a significant problem.

Finally, tamarisk, was selected as the third priority species. With approximately 1,500 acres of tamarisk, it is by far the most prevalent plant species in the Wash. Given the extent of the infestation, the fact that tamarisk provides habitat to a number of important birds, and the large amount of necessary resources to eradicate it, tamarisk will be addressed on a site by site basis, primarily as grade control structures and bank stabilization projects are implemented.

In addition to these priority weeds, the Partnership identified a number of "Watch Weeds." These are species that must be given consideration, and will be monitored and addressed as the needed. Watch weeds in the Wash include: Russian knapweed, Johnson grass, fountain grass, camelthorn, fivehook bassia, kochia, fan palm, silverleaf nightshade, and tree tobacco.

Weed Mapping

The Nevada Weed Action Committee (NWAC) has developed a Global Positioning System (GPS) protocol for mapping noxious weeds in Nevada. Weed mapping is an invaluable tool for assessing the extent of an infestation and planning effective weed management programs. Using a combination of aerial photography and GPS based ground surveys; tall whitetop, giant reed and tamarisk infestations in the boundary of influence have been mapped. The data has been submitted to NWAC for inclusion in its noxious weed database and GIS maps have been created to assist with treatment and management objectives.

Weed Management Techniques

A range of strategies associated with the management of weeds, from complete eradication to thinning existing stands or simply eliminating seed production to prevent further infestation, will be employed. Control actions include revegetation using native species, flood irrigation of weeds, fertilization to increase the population of more desirable species, and shading to starve the weed of needed sunlight. Mechanical methods can also be employed including hand pulling of weeds, mowing or cutting, tilling and burning. Biological controls, such as livestock, insects, fungi or other pathogens or predators can be employed to address weeds as well. In some cases, the most effective method for treating weeds requires the use of herbicides.

Integrated Weed Management

Integrated Weed Management (IWM) is defined as "a strategy of selecting and implementing a combination of weed control techniques or methods that collectively increase efficiency and effectiveness of treatment for a particular weed species or infestation"(Gershman & Lane, 2000). The goal of treatment for tall whitetop in the Wash is suppression, primarily using herbicide treatments in conjunction with hand pulling of select plants. This program is expected to take three to five years. Similarly, management of giant reed is accomplished using primarily herbicide treatment to eradicate the species. Eradication in this case is possible because the existing stands are isolated, small, and easily treated using herbicide. The goal for tamarisk is containment of existing stands, and suppression where possible. Treatment methods are primarily mechanical, including cut stump, root raking and hand pulling. In all cases, revegetation using native species is essential to effective long-term weed management. Without aggressive revegetation, treated weeds simply re-establish themselves, often in a short period of time.

Monitoring and Evaluation

Weed management is an ongoing, long-term endeavor, and constant monitoring and evaluation is required to ensure success. As a result, an effective monitoring strategy, which is simple and straightforward, will be used to periodically evaluate the effectiveness of particular treatment methods and success rates. The monitoring program will be used to adjust management strategies to maximize program effectiveness. The goal of the monitoring strategy is to encourage adaptive management, allowing the weed management program to be modified and

improved based on the ongoing collected data. Weed management and evaluation is an ongoing and imperative process that will be maintained to ensure effectiveness.

Community Involvement and Public Awareness

An important, yet often neglected component of any weed management program is community involvement and public outreach. Outreach with respect to weeds is doubly important given the public's overall lack of awareness about invasive plants in Nevada. To address this problem, the NWAC has initiated a statewide weed education program to coordinate and facilitate public outreach throughout the state. The Partnership has developed a number of key outreach materials. These include development of several web pages devoted to weeds at www.lvwash.org, profiles in agency publications, and television programs, as well as volunteer weed pulling events. In addition, the Partnership is working to develop a public outreach strategy to ensure that outreach activities undertaken by the Partnership are complimentary to, but not redundant with other state and local education programs.

Interagency Coordination

Established to collectively address the growing weed problem in the Wash, the Partnership has been successful because of the collaborations it has established. Contributions from member entities have ranged from technical advice and review, to the contribution of in-kind resources and funding of project components. As the Partnership moves forward, these collaborations will become increasingly important to maintain the established momentum.

CHAPTER 1

INTRODUCTION

The Las Vegas Wash (Wash) is a 12-mile urban waterway that carries flows from the Las Vegas Valley (Valley) to Las Vegas Bay in Lake Mead. Consisting of a combination of highly treated reclaimed water, shallow ground water, urban runoff and occasional storm flows, the Wash serves as the primary outlet for all urban flows from the 1,600 square mile hydrographic basin (Figure 1). Though this flow represents less than two percent of the total inflow to Lake Mead, it is a critical element in the overall environmental and water resource picture for southern Nevada.

Historically the Wash was an intermittent stream. However, with the introduction of urban flows in the 1950's, this desert wash burgeoned into a perennial stream and by the 1970's supported more than 2,000 acres of wetlands. As the population has increased so have flows in the Wash. The increase in daily flows has destabilized the channel, leaving the Wash susceptible to significant erosion during large storm events. This erosion has stripped the wetlands to a fraction of what existed 3 decades ago, increasing sediment transport to Lake Mead, decreasing wildlife habitat and creating a waterway vulnerable to further environmental deterioration.

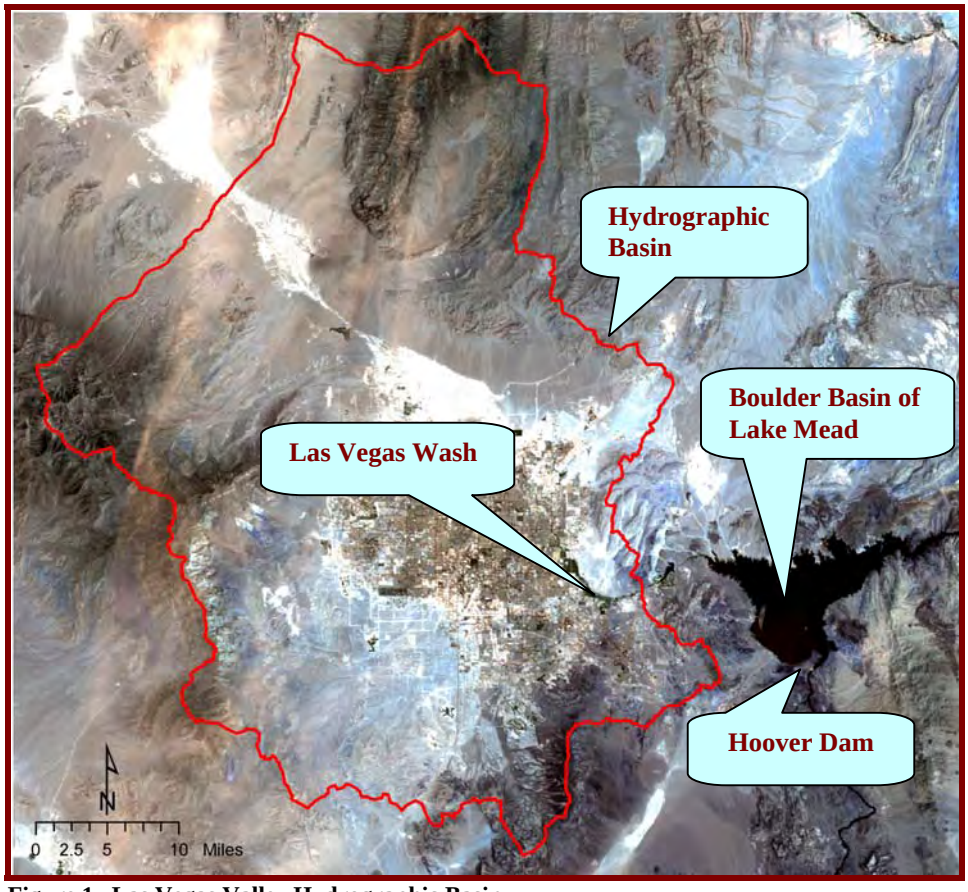

Figure 1. Las Vegas Valley Hydrographic Basin.

To promote awareness among the landowners and land managers within the hydrographic basin, facilitate cooperation and collaboration, create a weed control plan, and implement on-the-ground weed management activities in the lower Las Vegas Wash.

Las Vegas Wash Coordination Committee

In 1997, water quality concerns in Lake Mead prompted the formation of the Water Quality Citizens Advisory Committee (WQCAC). To help protect Lake Mead, the WQCAC made a series of recommendations to the Southern Nevada Water Authority (SNWA) that included the creation of a multi-stakeholder committee that would collectively develop and implement a framework for the stabilization and enhancement of the Wash. The Las Vegas Wash Coordination Committee (LVWCC) was formed in October 1998, consisting of 28 members, including representatives of local, state and federal agencies, environmental groups, local businesses and the general public. Since its inception, the LVWCC formulated a Comprehensive Adaptive Management Plan (CAMP) that outlines three key steps and 44 recommendations for the Wash. Based on these key steps and recommendations, the LVWCC has facilitated significant erosion control improvements, including the construction of seven grade control structures, installation of 3 miles of bank stabilization, mitigated 43 acres of wetland, riparian and upland habitat through revegetation of native plant species, and began a comprehensive water quality monitoring program and fish & wildlife studies.

The United States Army Corps of Engineers (COE) Section 404 permit requires mitigation to occur on an acre-for-acre basis for land disturbed during construction of grade control structures along the Wash. Permit requirements include an 80 percent survival rate of revegetation efforts with less than 20 percent cover by invasive plants. Invasive plants have been a common cause for the failure of mitigation in southern California (Allen and Feddema, 1996; Sudol, 1996).

As of 2000, an estimated 80 percent of the vegetation in the Wash was tamarisk *(Tamarix ramosissima)*, an invasive plant listed on the Nevada State Noxious Weed List (Nevada Weed List). Also this same year, 38 stands of giant reed (*Arundo donax*) were also identified in the Wash, a plant infesting thousands of acres of riparian areas in southern California. In 2001, tall whitetop *(Lepidium latifolium)*, otherwise known as perennial pepperweed and listed on the Nevada Weed List, was first identified in the LVWCC mitigation sites. Upon further investigation, it was identified throughout the lower Wash. The presence of invasive plants threatens the mitigation sites and serves as a potential for non-compliance with the COE Section 404 permit.

The Wash ecosystem is especially susceptible to invasive plants from the upstream tributaries and in turn serves as potential source for weeds in downstream Lake Mead and the Lower Colorado River. As a result, management of invasive plant species is an important component in the stabilization and enhancement of the Wash. In order for the revegetation efforts in the Wash to be successful, invasive plant management must be addressed from a watershed perspective**.**

The channel stabilization and invasive plant management effort will help foster the healthy establishment of native plant communities through revegetation and natural recruitment that will increase habitat value, improve water quality, reduce soil degradation and increase bank stabilization in the Wash.

Las Vegas Wash Weed Partnership

Understanding the characteristics of invasive plants is important to the development of a long-term weed management strategy. It is necessary to include partners across jurisdictional boundaries throughout the watershed to effectively address invasive plant issues in the Wash and its associated tributaries. With the goal of providing a collaborative means for developing an integrated weed management strategy for prevention, management, and eradication of these plants, the SNWA initiated the formation of the Las Vegas Wash Weed Partnership (Partnership). Through a grant from the National Fish and Wildlife Foundation Pulling Together Initiative the Partnership was formed in June 2002. The purpose outlined in the grant was to establish a weed management area to provide a foundation for developing an Integrated Weed Management Plan, conduct weed control activities, improve public awareness of weeds, and pursue additional funding.

The mission of the Partnership is to promote awareness among landowners and land managers within the hydrographic basin, facilitate cooperation and collaboration, create a weed management plan, and implement on the ground weed management activities in the lower Wash.

LAS VEGAS WASH
WEED PARTNERSHIP MEMBERS

City of Henderson
City of Las Vegas
City of North Las Vegas
Clark County Parks and Community Services
Clark County Public Works - Vector Control
Lake Las Vegas Resort
Nevada Department of Agriculture
Southern Nevada Water Authority
United States Bureau of Reclamation
United States Fish and Wildlife Service
United States National Park Service
United States Department of Agricultural Natural Resources Conservation Service
University of Nevada Cooperative Extension

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CHAPTER 2

DESCRIPTION OF AREA

Boundary of Influence

The boundary of influence established by the Partnership is the lower Las Vegas Wash, defined as the nine-mile stretch of the Wash located from Vegas Valley Drive to Lake Las Vegas (Figure 2). From Vegas Valley Drive north of the Clark County Wetlands Park (Wetlands Park), the boundary of influence includes the Wash and its adjacent banks and then widens to include the Wetlands Park boundary. Though the lower Wash is just one portion of the Las Vegas Valley watershed, it currently has a high concentration of weeds and is a major seed source for Lake Mead and the Lower Colorado River system. Partnership efforts in the Wash will work in tandem with activities outside of the established boundary of influence. The current boundary may expand as deemed appropriate in the future.

Figure 2. Boundary of Influence for the Las Vegas Wash Weed Partnership.

Natural Resources

Vegetation

In 1998, vegetation communities in the Wash were identified and mapped by the Southwest Wetlands Consortium as part of the Clark County Wetlands Park Environmental Impact Statement. While the survey identified nine vegetative communities, the LVWCC is currently conducting a more comprehensive vegetative community analysis and delineation.

Vegetative analysis within the boundary of influence also includes botanical inventories conducted by the LVWCC in June and October of 2002. To date, 104 plant species have been identified (see Appendix A for complete list). Majorities of the species identified exhibit perennial growth (i.e. persistent growth through all seasons). The presence of plants exhibiting annual growth may increase the number of species identified significantly if present drought subsides in future years.

More than 60 of the plant species identified are native to the lower Colorado and the Wash. Some particularly beneficial native species include salt heliotrope (*Heliotropium curassavicum*) and emory waterweed (*Baccharis emoryi*). The former provides good ground cover and both species are excellent nectar sources for insects. Beneficial species, such as these discovered during the inventory, are being examined for possible use in revegetation planning along the Wash. To date, no rare or sensitive plant species have been identified.

NINE PLANT COMMUNITIES IDENTIFIED IN THE WETLANDS PARK EIS

1) Emergent wetland/hydroriparian
2) Strand
3) Common reed
4) Tamarisk
5) Alkali
6) Disturbed
7) Upland
8) Xeroriparian

The remaining species identified are non-native. Although many of these pose little threat to the Wash, a few are considered to be highly invasive. The identification of populations of invasives such as Russian knapweed *(Acroptilon repens)* and tall whitetop assists invasive plant managers in targeting areas for control. These and other invasive plant species are discussed in further detail in Chapter 4.

Samples of identified plants collected in the field were used to create museum-sized herbarium sheets. The sheets will be used to train staff in plant identification while also being stored as a herbarium collection. The LVWCC will perform floristic inventories periodically over time, which will assist invasive plant managers with their monitoring efforts.

Soils

The US Natural Resources Conservation Service recently completed a soil survey database for the Wetlands Park. The soil survey database provides detailed information and was designed primarily for the Clark County Parks and Community Services (CCPCS) to assist with natural resource planning and management. Using soil attributes, this database serves as an excellent source for: 1) identifying erodible areas and developing erosion control and prevention practices 2) reviewing site development proposals and land use potential 3) making land use assessments and chemical fate assessments and 4) identifying potential wetlands, sand and gravel aquifer areas. The database also identifies physical and chemical soil properties. Data on each location includes the following: flooding, depth to bedrock, water table depth and soil subsidence. Use and management sustainability recommendations include: sanitary facilities, construction material, building site development, recreational development, water management and wetland wildlife habitat suitability.

DATA FOR EACH MAJOR LAYER OF SOIL INCLUDES:

1) Particle size distribution
2) Soil reaction
3) Bulk density
4) Salinity
5) Available water capacity
6) Organic matter

Water Quality

Figure 3. Water Quality monitoring using a Hydrolab multi-parameter probe.

As the sole drainage of the Las Vegas Valley watershed, the Wash consists of four flow components; urban runoff, highly-treated wastewater from three wastewater treatment facilities, shallow groundwater, and storm water. To establish baseline water quality information and evaluate the effects of wetlands on water quality over time, a comprehensive monitoring plan has been implemented beginning in 2000 (Figure 3). Data collected in the past three years shows electrical conductance (EC) values in the mainstream Wash water range from 2100 to 2500 µS/cm, which implies total dissolved solid (TDS) concentrations in the water range from 1400 to 1675 mg/L. The average pH values are around 8.0, the average temperature between 21ºC and 24ºC, and dissolved oxygen (DO) concentrations are from 7 mg/L to 9 mg/L.

Cations are dominated by calcium, magnesium, potassium, and sodium, whereas anions are dominated by sulfate, chloride, bicarbonate, and silica. Among 21 heavy metals analyzed, several of them are below detection limits. Aluminum, iron, and manganese have a wide average concentration range (from 1.0 ug/L to 799 ug/L). Arsenic, barium, chromium, copper, lead, zinc, and selenium were lower than the Maximum Contamination Level (MCL) for the primary and secondary standards under the Safe Drinking Water Act. The average perchlorate value in the Wash ranges from 20 ug/L at Upstream City of Las Vegas to approximately 400 ug/L at Northshore Road.

About 94 percent of the nitrogen found in Las Vegas Wash is elemental nitrogen, mostly as nitrate (NO_3-N). This means there is only minor contribution from biological material. There is very little change in the average concentration proceeding downstream indicating that there is more than enough nitrogen in the system for biological activity. However, at the Historic Lateral Weird there is almost a 50% drop in nitrogen concentration. About 70 % of the phosphorus concentration is soluble phosphate (PO_4-P), again indicating that there is less contribution of biological material and that there is abundant soluble phosphate for plant growth. The fact that there is a nearly 50 % drop in phosphate from the Historic Lateral Weir downstream indicates that the soluble phosphate is either being tied up in sediments or used in biological growth. There is little to no apparent drop in average concentration further downstream.

Fish and Wildlife

The Wash is home to more than 300 species of amphibians, birds, mammals, reptiles and fishes (Clark County, 1998). To help determine the effects of the channel stabilization improvements

on wildlife and habitats, the LVWCC has implemented several biological monitoring programs to identify species and create baseline population data. This data will then be used to develop long-term fish and wildlife monitoring plans for the Wash.

Studies currently underway include a bird census, reptile, fish and small mammal surveys (Figure 4). The bird census began in November 2001, and identified 125 avian species from 44 families in its first three years. Bird sightings of interest include the peregrine falcon, phainopepla, and blue grosbeak, which are species of Clark County Multiple Habitat Conservation Plan (CC MSHCP) concern. The reptile survey completed its second field season in October 2002 and identified a total of 15 species. Common captures include the western whiptail lizard, which accounts for approximately 80 percent of the reptiles caught, and the side-blotched lizard. The fish and small mammal surveys were both conducted over one year, beginning in summer 2002. Seven species of non-native fish were identified, including mosquitofish and black bullhead catfish. To date, no native fishes to the Wash were found on the survey. Eleven species of small mammals were caught during the surveys. For a complete species list refer to Appendix B.

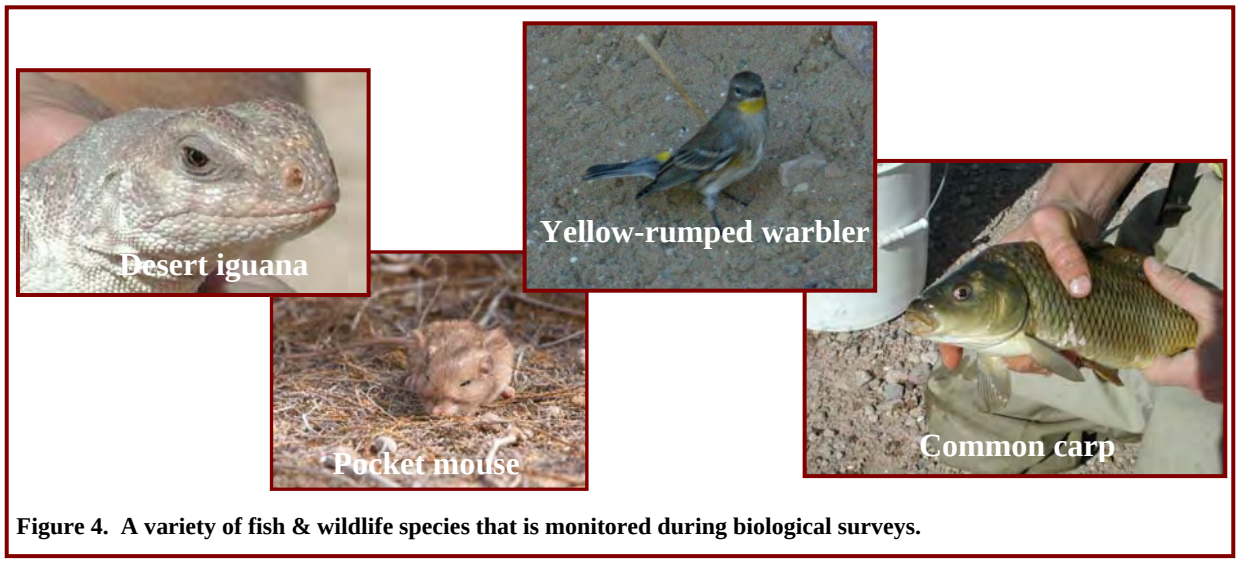

Figure 4. A variety of fish & wildlife species that is monitored during biological surveys.

Other CC MSHCP species that have been observed during these surveys include the western-banded gecko and desert pocket mouse (for a full list refer to Appendix B). The LVWCC will begin two new baseline surveys in 2003-2004 fiscal year for bats and amphibians.

Land Ownership

Most of the land within the boundary of influence is public although there are still a few (Figure 5) parcels that are privately owned within the Wetlands Park boundary. CCPCS is currently working to acquire the remaining private land. Acquiring the remaining private land will make management of the Wash easier and more effective.

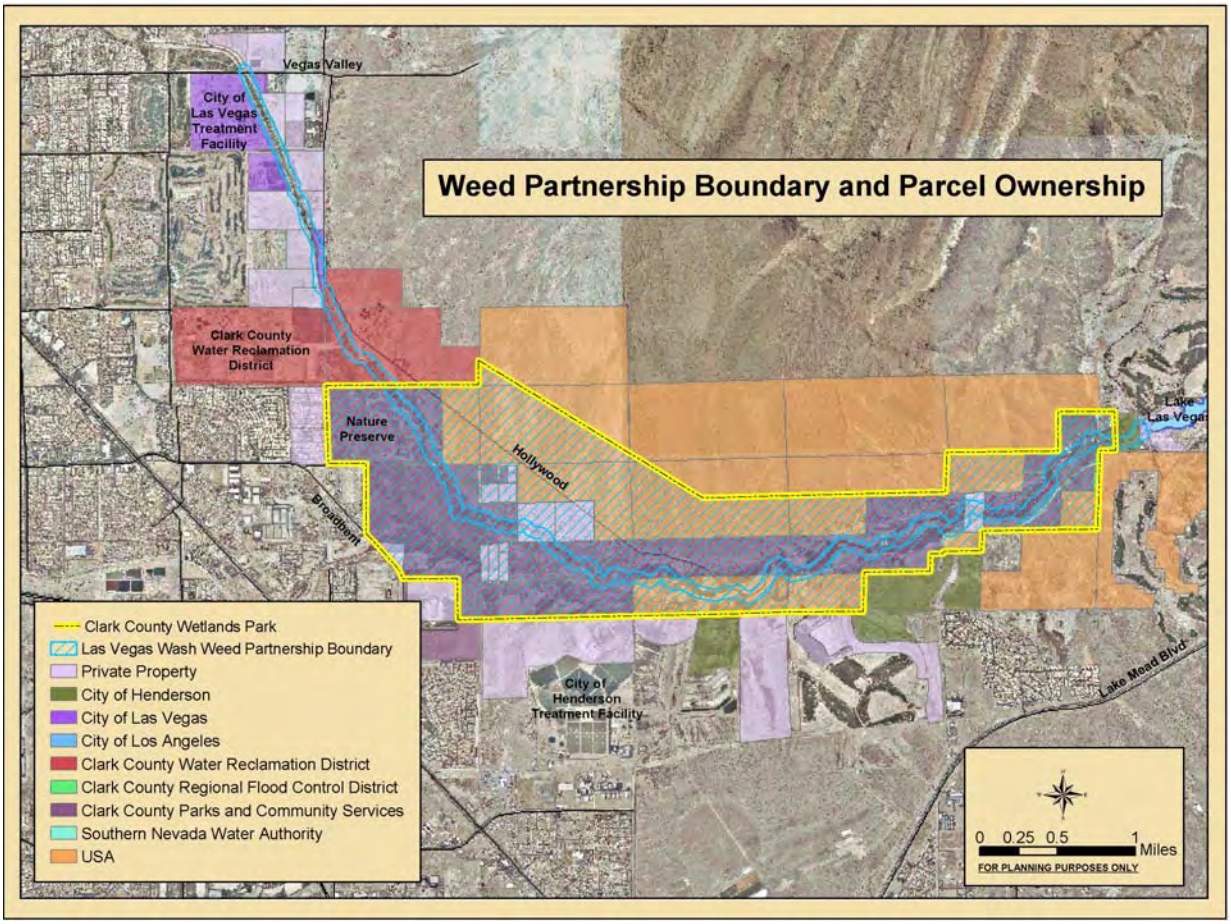

Figure 5. Weed Management Boundary and Parcel Ownership for the lower Las Vegas Wash area.

Stabilization and Enhancement Activities

Erosion Control

The Wash is a dynamic system with highly erodible soils. Increased daily highly treated wastewater treatment and urban run-off flows and large storm events have caused significant erosion over the past few decades. This has resulted in the loss of over a thousand acres of wetlands and increased sediment loads carried into Lake Mead at Las Vegas Bay. In an effort to slow this erosion and stabilize the channel, the LVWCC has constructed seven grade control structures (weirs) and installed rock riprap along several miles of Wash banks. The Las Vegas Wash Capital Improvement Plan (LVWCIP), 2002, outlines the long-term plan to construct additional structures and perform further bank and channel stabilization activities over the next ten years. These erosion control activities will provide opportunities to clear large areas of tamarisk during site preparation. However, soil disturbance caused by construction activities could provide opportunities for invasive plant species to colonize.

Cut bank upstream of Pabco Weir.

Historic Lateral Weir.

Mitigation

The COE Section 404 permit requires the LVWCC to mitigate on an acre-per-acre basis, the land disturbed by the installation of grade control structures. To date, 43 acres have been revegetated with more than 12,000 wetland, riparian, and upland plants. An example of a revegetation design for the South Bank and Sandbar Site is shown in Figure 6. The LVWCC uses species native to the Wash and Lower Colorado River, and uses local stock as means to enhance survival rate where possible. The COE Section 404 permit requires mitigation efforts to have an 80 percent survival rate with less than 20 percent encroachment by invasive plant species. Consequently, the planting sites are well monitored and maintained with assistance from the National Division of Forestry (NDF) Conservation Camp crews, Native Resources and other contractors.

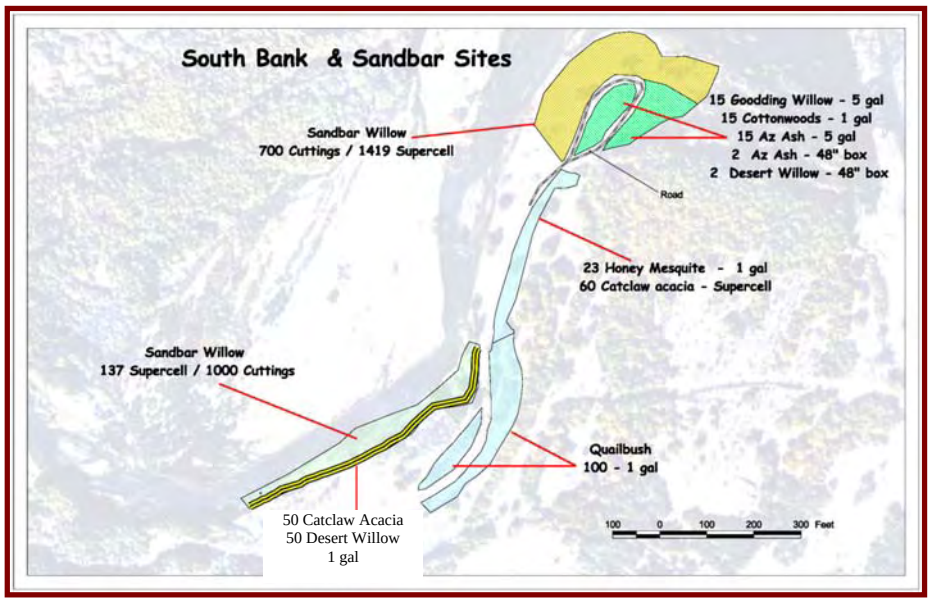

Figure 6. More than 43 acres have been revegetated in conjunction with the channel stabilization program.

CHAPTER 3

SIGNIFICANCE OF INVASIVE PLANTS

Impacts of Weeds

Invasive plants negatively impact millions of acres of land nationwide. In the western United States alone, invasive weeds have infested more than 890 million acres. However, this problem is caused by a relatively small number of species in comparison with the total number of non-native plants growing in the US or being introduced each year. Few introduced plants actually cause a problem at all (Nevada's Coordinated Invasive Weed Strategy, 2002).

For example, out of 1,500 plant species in the Great Smoky Mountain National Park, 400 species are non-native but only 10 of those appear to pose a threat to park resources (Hiebert, 1997).

Figure 7. Tamarisk species were first introduced as windbreak and ornamental plants.

Plants are intentionally introduced with many aesthetic and functional values including flowers, fruit, windbreak protection and bank stabilization (Figure 7). Non-native plants are also introduced unintentionally as contaminants in seed grain, packaging material, bilge or ballast water, attached to vehicle and tires, or carried by natural means (such as water), NWAC, 2002. The process of invasion is difficult and the possibility of a species to becoming invasive in a new environment is unlikely.

The process of invasion is as follows. If a new species is introduced it must first become established in the new environment which is dependant upon both survivability and its ability to reproduce. It must become naturalized that is, adapted to the local conditions, which may require a long period of selection and hybridization with native species. This step may also result in a lag period before rapid expansion. The final step in the invasion process is dispersal throughout the new environment.

Though a relatively small percentage of introduced plants overcome these obstacles and become invasive, those few plants can cause a tremendous amount of economic and ecological damage (Holt, 2002). Most invasives in the United States have been traced back to Europe or Asia. In their native ecosystem, these plants were in balance with the system, controlled by competing plants, plant pathogens and predatory insects. Without these controls the plant has the opportunity to spread, unchecked, often until it is a monumental problem (Nevada's Coordinated Invasive Weed Strategy, 2002).

> A noxious weed is "any species of plant which is, or likely to be, detrimental or destructive and difficult to control or eradicate." – U.S. Department of Agriculture

Classifications of Weeds and Nevada Weed Law

A plant is considered a *weed* if it is located where it is not wanted. Where this designation is somewhat subjective, it can be site specific and may not be

based on whether the plant is native or not. The term *invasive* refers to a plant's ability to rapidly reproduce and spread. These plants ultimately out-compete all other vegetation in an area to form dense stands composed almost entirely of this single unwanted species (Nevada's Coordinated Invasive Weed Strategy). The United States Department of Agriculture, defines a *noxious weed* as a "species of plant that causes disease or is injurious to crops, livestock or land, and thus is detrimental to agriculture, commerce or public health". Once an invasive plant is designated as noxious, it is elevated to a status that carries regulatory authority.

Like many other states, Nevada regulates the control of noxious weeds. As part of the Nevada Revised Statutes (NRS), Nevada has developed a State Noxious Weed List (Table 1). The State of Nevada's noxious weed law places the responsibility for noxious weed control on all landowner-occupiers. According to NRS Chapter 555.160-180, every landowner or occupier, whether private, city, county, or federal, shall cut, destroy, or eradicate all noxious weeds. The NDOA can serve notice to owners-occupiers of the action they must take to address their noxious weed problems. If the owner-occupier refuses to comply, NDOA will notify the County Commissioners who must then perform the required control actions, paying for them out of county funds. The county then bills the owner-occupier for the cost of performing the work. In turn, the owner-occupier can file an objection with the county. The County Commissioners may determine that some or all costs are to be borne by the owner-occupier and may, as a last resort, collect the cost of control through a tax lien on the land. However, this mechanism is rarely used. Most

TABLE 1. NEVADA STATE NOXIOUS WEED LIST

Common Name	Scientific Name
African rue	*Peganum harmala*
Austrian fieldcress	*Rorippa austriaca*
Austrian peaweed	*Sphaerophysa salsula/ Swainsona salsula*
Black henbane	*Hyoscyamus niger*
Camelthorn	*Alhagi pseudalhagi*
Canada thistle	*Cirsium arvense*
Carolina horse-nettle	*Solanum carolinense*
Common crupina	*Crupina vulgaris*
Dalmation toadflax	*Linaria dalmatica*
Diffuse knapweed	*Centaurea diffusa*
Dyer's woad	*Isatis tinctoria*
Eurasian water-milfoil	*Myriophyllum spicatum*
Giant salvinia	*Salvinia molesta*
Goats rue	*Galega officinalis*
Green fountain grass	*Pennisetum setaceum*
Hoary cress	*Cardaria draba*
Houndstongue	*Cynoglossum officinale*
Hydrilla	*Hydrilla verticillata*
Iberian starthistle	*Centaurea iberica*
Klamath weed	*Hypericum perforatum*
Leafy spurge	*Euphorbia esula*
Malta starthistle	*Centaurea melitensis*
Mayweed chamomile	*Anthemis cotula*
Mediterranean sage	*Salvia aethiopis*
Medusahead	*Taeniatherum caput-medusae*
Musk thistle	*Carduus nutans*
Poison hemlock	*Conium maculatum*
Puncture vine	*Tribulus terrestris*
Purple loosestrife	*Lythrum salicaria,*
Purple starthistle	*Centaurea calcitrapa*
Rush skeletonweed	*Chondrilla juncea*
Russian knapweed	*Acroptilon repens*
Saltcedar (Tamarisk)	*Tamarix ramosissima*
Scotch thistle	*Onopordum acanthium*
Sorghum species, perennial, including, but not limited to: (a) Johnson grass; (b) Sorghum alum; and (c) Perennial sweet sudan	
Sow thistle	*Sonchus arvensis*
Spotted knapweed	*Centaurea biebersteinii*
Squarrose knapweed	*Centaurea triumfettii*
Sulphur cinquefoil	*Potentilla recta*
Syrian bean caper	*Zygophyllum fabago*
Tall whitetop (Perennial pepperweed)	*Lepidium latifolium*
Water hemlock	*Cicuta maculata*
Silver leaf nightshade	*Solanum elaeagnifolium*
Yellow starthistle	*Centaurea solstitialis*
Yellow toadflax	*Linaria vulgaris*

landowners-occupiers comply with the laws when notified and advised of the problem.

Some of the listed species are ubiquitous throughout the state, such as tamarisk, and some species such as Eurasian water milfoil, have yet to be found in southern Nevada. In addition to the species on the Nevada Weed List, other plants may be of concern in the Wash. Giant reed is a serious problem along riparian corridors in Arizona and southern California and is listed on the California Noxious Weed list. Giant reed is present in the Wash, and may pose a problem in the future, though it is not currently listed on the Nevada Weed List. To address species such as giant reed, considerations should be made on a case-by-case basis to determine when management actions are necessary and for which species regardless of the state's designation for a particular plant.

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CHAPTER 4

WEED MANAGEMENT PRIORITIES

Weed management priorities are based on the actual or potential threat that weeds pose to the management goals for a project area. Considerations are given to weed species and location of weed infestations when setting priorities. Weed species vary considerably in the threat they pose to resource values and vary greatly in their susceptibility to control measures. Weed species that pose the highest risk toward achieving the management goals for the project area need to be controlled immediately and should be the highest priorities for management**.** However, if the location of an infestation is especially vulnerable or has other important values that are at risk, the infestation at a particular location may be rated high even if it is not a high priority weed (Gershman & Lane, 2000).

Priority Weeds

The Partnership has identified three priority weeds of concern for the Wash: tall whitetop, giant reed and tamarisk (Table 2). The ranking was based on threat to the ecosystem, size of infestation, potential for control, and established control programs.

TABLE 2. PRIORITY WEEDS

Common name	Scientific name	Ranking
Tall whitetop	*Lepidium latifolium*	1
Giant reed	*Arundo donax*	2
Tamarisk	*Tamarix ramosissima*	3

Tall Whitetop (*Lepidium latifolium*)

Figure 8. Tall whitetop

Tall whitetop, Perennial pepperweed, (Figure 8) was first identified in the Wash by Clark County Public Works – Vector Control (Vector Control), near Vegas Valley Drive in 1995. In March 2001, it was found farther downstream in LVWCC mitigation sites. At that time, tall whitetop had a wide distribution but was generally found at low densities. It was estimated to total less than two acres throughout the Wash. In 2002, visual estimates were made and tall whitetop was found in patches throughout the entire length of the Wash. The fact that tall whitetop has only recently invaded this area means that there still may be an opportunity to control this noxious weed. Registered on the Nevada Weed List and regulated by law, tall whitetop ranked as the first priority species for the Partnership because of the pernicious nature of the weed, the potential for control early in the Wash and the threat to Lake Mead and the lower Colorado River system. Control of this plant is anticipated to take three to five years, with the first year of on-the-ground control activities completed in fall 2002 to spring 2003, (Figure 9). The goal of tall whitetop in the Wash system is suppression.

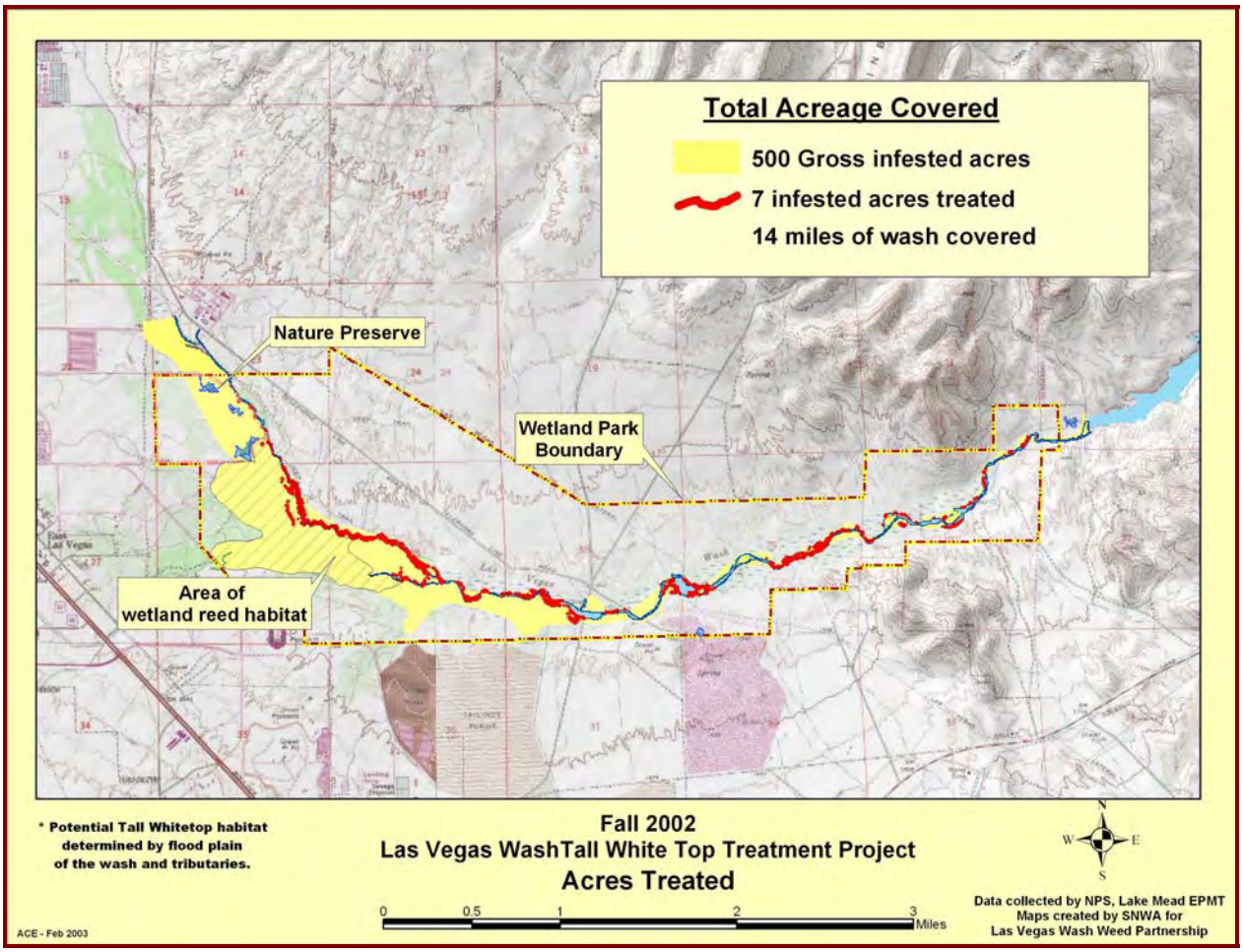

Figure 9. Total acreage covered in the fall of 2002 by the National Park Service Exotic Plant Management Team (NPS EPMT) for the tall whitetop project.

Giant Reed (Arundo donax)

Figure 10. Giant Reed

Giant reed (Figure 10) is in the early stages of infestation in the Wash. Currently exists in isolated stands, to date 38 stands have been identified and mapped in the Wash (Figure 11). Though not listed on the Nevada's Noxious Weed List, it is listed in the State of California and has caused significant problems in riparian areas throughout the state. As such, giant reed has the potential to become a noxious weed in southern Nevada and should be controlled in the Wash system before it becomes a problem. The Partnership ranked this weed as its second priority.

To date, the Vector Control has treated the majority of stands of giant reed in the Wash. The National Park Service (NPS) has been contracted to treat the remaining stands as part of their treatment activities. The goal for giant reed is eradication.

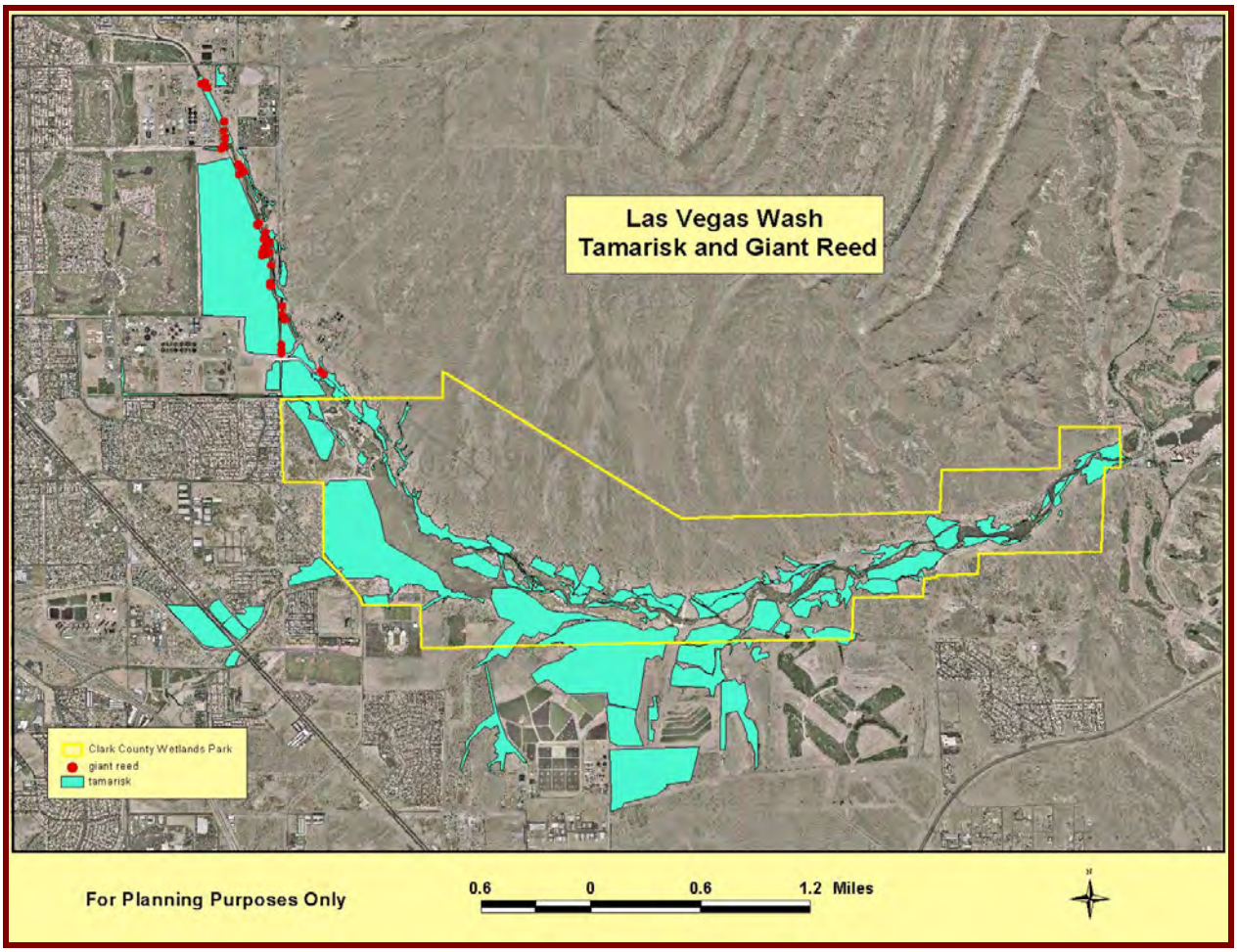

Figure 11. Tamarisk and giant reed distribution in the Las Vegas Wash.

Tamarisk (Tamarix ramosissima)

Figure 12. Tamarisk.

Tamarisk (Figure 12) also known as saltcedar, has been ranked third in the Partnership's priority list. Aerial photography, mapping have been completed for tamarisk in the Wash. There are currently 1,500 acres of tamarisk infesting the Wash (Figure 11). Because tamarisk serves as potential habitat to the Southwestern willow flycatcher, as well as providing structure for all species, tamarisk is removed only in specific areas based on the Wash's revegetation program. At this time, the goal for the tamarisk management program is containment of the existing stands where feasible and control tamarisk growth in the revegetation sites.

Watch Weeds

In addition to the Nevada Weed List, consideration must also be given to other southwestern riparian weeds of concern. A list of Watch Weeds has been developed to include plants that have the potential to infest southern Nevada from neighboring states or other habitats. The following table (Table 3) lists the additional weed species that were identified as Watch Weeds based on their known distribution, potential for invasion and/or nuisance. Additional species will be added to this list as they are identified.

TABLE 3. WATCH WEEDS

Common name	Scientific name	Status
Russian knapweed	*Acroptilon repens*	present
Johnson grass	*Sorghum spp.*	present
Fountain grass	*Pennisetum setaceum*	potential
Camelthorn	*Alhagi pseudalhagi*	potential
Fivehook bassia	*Bassia hyssopifolia*	present
Kochia	*Kochia scoparia*	present
Fan palm	*Washingtonia filifera*	present
Silverleaf nightshade	*Solanum elaeagnifolium*	present
Tree tobacco	*Nicotiana glauca*	present

Another tool that may be helpful in ranking weeds in the future is the Noxious Weed List Tiering Structure that the NDOA is currently drafting. This system provides a strategy for prioritizing weeds for management. The NDOA will conduct abatement procedures on those species placed in Categories A & B. Abatement is at the discretion of NDOA on those species in Category C, but they are still subject to NRS 555.

The categories are defined as follows:

CATEGORY A: These noxious weeds have not been detected in the state or are found in small, scattered localized infestations. Many of these weed species are found in neighboring states and may cause serious degradation to lands in Nevada. Management actions should focus on immediate treatment for eradication.

CATEGORY B: These noxious weeds have recently been introduced into the state or are rapidly spreading from their current infestation sites. Many of these species are found throughout Nevada or may not pose as serious a threat as Category A species. Management actions should focus on treatment to control existing infestations and prevent new infestations sites.

CATEGORY C: These noxious weeds are weeds that are currently established and generally widespread in many counties of the state. These species are found in large infestations and management actions should be taken to control where possible and prevent new infestation sites.

CATEGORY Q: Weeds rated in this category would indicate that a State or Federal quarantine exists for the weed and action would have to be taken immediately to control and eradicate the weed.

Weed Infestations

Prioritizing weed infestations is an important component of the weed management strategy. It allows for selecting weed control activities that will yield the greatest effect in meeting land management goals and objectives. Among other factors, limited resources may sometimes not allow all the priority weeds to be addressed at a given time (Gershman & Lane). Such is for tamarisk in the Wash. With 1,500 acres, complete treatment is not feasible and not desirable, as tamarisk does provide structure and cover for some wildlife and serves as potential habitat. Thus, after prioritizing the weed, each infestation should also be ranked individually. Management actions should be based on factors such as location and extent of the infestation. According to Neill (1997), priority should be given to "…isolated patches of the highest priority weed species first. Two reasons to adopt this strategy: 1) to increase the efficiency of control efforts, and 2) the psychological reward. Weeds spread from existing infestations. To reduce the spread of weeds, it makes sense to limit the number of new infestations. Such infestations are typically small and easily controlled because they have less well developed root systems, less stored food reserves in roots and rhizomes, and smaller seed banks in the soil. Controlling isolated patches also gives a landowner or manager a sense of accomplishment, providing the motivation to persist in weed control efforts. High efficiency means gaining control of a weed species problem with a minimum of effort". High priority infestations are characterized as: 1) small, isolated infestations, 2) patches of high priority weeds, and 3) areas of frequent disturbance, such as streams and roadsides. Low-priority weed infestations include large infestations of low-priority weed species, especially species that are easy to control even if left unmanaged. Large infestations of high-priority weed species may be low-priority for control if they present an exceptionally large weed management challenge (Gershman & Lane).

Tall whitetop infestation at the Wash.

LAND MANAGEMENT GOALS AND OBJECTIVES

Given the known conditions for the Wash, current management programs and planned management actions based on the CAMP document, the Partnership developed specific goals and objectives for the boundary of influence to serve as the foundation for weed priorities and the selection of weed management actions. These goals and objectives are beneficial because they help make more efficient use of limited resources, focus time and money on important natural resources, enable selection of the most important weed species and infestations to control and provide specific criteria for evaluating the effectiveness of control actions. Additionally by identifying goals and objectives the focus is placed on weed management goals (where people are more likely to find a common ground) rather than solely on control actions (where people are less likely to agree), and thereby increase accountability. Management goals identified are brief statements that describe the desired conditions within the management area. The focus includes human values, natural resources and/or financial resources (Gershman & Lane).

The Partnership developed the following goals:

1. **Contribute to the protection of the watershed.**
2. **Promote native plant communities.**
3. **Identify new invasive weed species invasions early.**
4. **Improve the upland, riparian, and wetland areas within the Las Vegas Wash boundaries.**
5. **Complete a plant inventory of the Las Vegas Wash.**
6. **Create a strategy to address wildfire rehabilitation.**

Weed management objectives are achievable, specific, measurable statements with deadlines and apply to a specific location. The objectives are tied to the very general goals and specific action steps. The objectives are consistent with state regulations, but additional weed species may be selected for management actions that are not listed on the State Noxious Weed List if identified as a nuisance for the project boundary (Gershman & Lane).

The Partnership developed the following weed management objectives:

1. **Maintain less than 20 percent invasive species cover in restoration sites.**
2. **Treat and control existing stands of giant reed *(Arundo donax)* from the Wash and Wetlands Park over the next year (June 2003- May 2004).**
3. **Continue treatment and monitoring for significant control of tall whitetop aka perennial pepperweed (*Lepidium latifolium*) in the Wash and Wetlands Park over the next year (June 2003- May 2004).**
4. **Control tamarisk (*Tamarix ramosissima*) associated with erosion control and bank stabilization improvements.**
5. **Identify desirable native plant species of the Colorado River drainage for a revegetation program.**

The goals and objectives defined above are designed to be a tool in the establishment of a strategy for weed management. As management actions are implemented, the goals will be revisited, adjusted as necessary. The objectives will help guide the annual work plan and will be reviewed each year.

CHAPTER 5

WEED MAPPING

Weed mapping is an important tool in effective weed management programs. Mapping inventories provide useful information on the species present, the extent of the infestation, and then can serve as the basis for monitoring programs. The information may also be used to set priorities for weed species and specific infestations. Unfortunately, many aspects of the Wash pose a difficult challenge for inventories. Access is difficult in many areas of the Wash due to dense tamarisk stands, channelization and steep eroded banks. Formal surveys should be conducted annually and due to access difficulties, this may coincide with treatment actions. Time of year the survey is conducted is dependent on the species of interest. Casual observances should also be recorded from field personnel. To follow through with this all field personnel will be trained to identify weeds of concern in the Wash.

TABLE 4. WEED DATA DICTIONARY FOR A POINT FEATURE

Weed_Species	**Cover_Class_%, numeric**
"Arundo"	**Phenology**
"Black henbane"	"Mixed", default
"Canada thistle"	"Rosette"
"Cocklebur"	"Seedling"
"Dalmatian toadflax"	"Bolting"
"Diffuse knapweed"	"Bud"
"Dyer's woad"	"Flowering"
"Hoary cress"	"Seed Set"
"Houndstoungue"	"Maturity"
"Johnson grass"	"Senesced"
"Leafy spurge"	**#_of_Plants, numeric**
"Musk thistle"	**Plant_Diameter, numeric**
"Poison hemlock"	Offset
"Russian knapweed"	"NO", default
"Saltcedar"	"YES"
"Scotch thistle"	**Notes**
"Spotted knapweed"	**Name_of_Mapper**
"Squarrose knapweed"	Party, text
"Sulfur cinquefoil"	GPS_Agency, text, WASH TEAM
"Tall whitetop"	GPS_Type, text, Trimble Pro XRS
"Western water hemlock"	Date, date, auto
"Rush skeletonweed"	Time, time, auto
"Wild licorice"	
"Other"	
"Unknown"	
Size_of_Infestation	
"T - <0.1"	
"S - 0.1-1"	
"M - 1-5"	
"L - >5"	

The Nevada Weed Action Committee (NWAC) has developed a Global Positioning Systems (GPS) protocol for field mapping of noxious weeds in Nevada. This manual has been adapted in large part from **Mapping Noxious Weeds in Montana** by Diana Cooksey and Roger Sheley, a system widely adopted in the West. The data standards for Nevada's protocol include collecting point, line and area features for weed species. At a minimum, all three features should include the following attribute information: name of the person collecting the data, type of GPS unit used, coordinates of the infestation, observation date, species (by weed symbol if appropriate), and cover class. The point data type should also include the size of the infestation (i.e. the approximate point diameter), whereas the line record should include the width of linear infestation (Table 4). When appropriate, additional

information should be collected when mapping weed infestations in the Wash, such as the phenology of the plant and treatment method, along with any other comments of interest and native plants present among weeds.

All data collected will be submitted to the state noxious weed database developed by the NWAC, through the mapping coordinator for the CC-MSHCP. Data is compiled statewide in a uniform format and converted into a GIS map that is available on the NWAC Web site, http://agri.state.nv.us/nwac and as in insert as Figure 13. This map helps provide a statewide perspective for tracking the spread of existing infestations and allows land managers to anticipate the introduction of new weed species from neighboring areas. Potential weed introductions should also be considered from surrounding states in addition to adjacent properties.

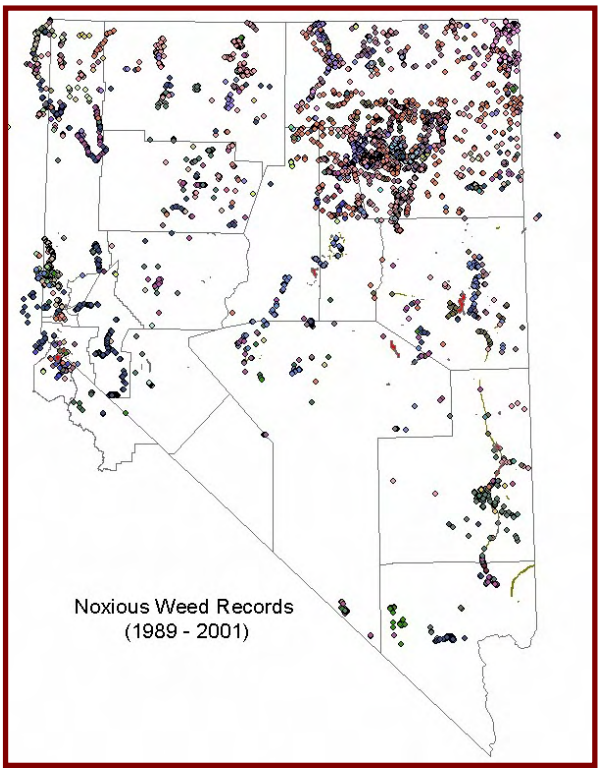

Figure 13. Map of Nevada weed infestations as of 2001.

Weed Mapping Alignments

As of December 2002, the Wash has been surveyed for tall whitetop, giant reed and tamarisk. Tall whitetop and giant reed have been mapped via ground surveys; aerial photography was used to determine the extent of the tamarisk infestation (Figure 11).

In addition to submitting records to the state database for the state weed map, GIS maps are created with the weed data collected for use in the Wash. Maps and associated databases are used to track treatment techniques, areas of large or difficult to treat infestations, water quality monitoring sites and access points. GIS technology also provides information on site selection for treatment techniques based on the size and/or location of the infestation. The maps created assist in monitoring the efficacy of treatments and calculating acreage. Weed mapping will be conducted on an annual basis or as necessary.

CHAPTER 6

WEED MANAGEMENT TECHNIQUES

There are a variety of techniques proven effective for weed management, including prevention, cultural, mechanical, biological, and chemical. The most appropriate management action should be chosen based on the weed species, the physical characteristics of each site, and economic and social considerations.

TECHNIQUES FOR WEED MANAGEMENT

- Prevention
- Cultural
- Mechanical and biological
- Herbicide treatment
- Prescribed burns

Several factors should be considered when selecting tools for a weed management program. It is important to understand the underlying causes of weed infestations at the site and work not only on treating the existing weeds, but also treating the cause of the infestation. Weed invasion and establishment may continue regardless of the treatment program if the underlying causes aren't addressed as well.

Another factor to consider is that a single control technique may not be sufficient to control a particular weed species. Each method has benefits and limitations and not all methods are feasible for each situation. Often the most effective control requires a combination of techniques. This process is called "integrated weed management". Integrated weed management (IWM) employs more than one weed control method. The techniques work in tandem with each other to control a weed species or infestation while minimizing adverse impacts to non-target organisms. A third factor to consider when implementing a weed management program is the desired level of control for that particular species or infestation. This should be based on the goals and objectives outlined in the weed management plan. According to Gershman & Lane, the different levels for control are:

THE EASIEST WEED TO ERADICATE IS THE FIRST ONE.

- ERADICATING a population of a weed species (including seeds);
- KILLING an entire population of plants with the expectation that the plant will repopulate an area from seeds in the soil;
- WEAKENING established plants so that they will be more susceptible to mortality in the future or that their seed production will diminish;
- THINNING plants, where some plants in a population are killed but many are not; and
- ELIMINATING seed production by damaging the top growth of plants (Gershman & Lane).

Eradication is usually only feasible for small populations of high priority species. This is because, in general a large amount of resources are required for this level of control. Weed infestations are typically targeted to a level of control that is located somewhere in between eradication and elimination of seed production (Gershman & Lane).

Weed Prevention

Of all of the weed control actions, prevention is by far the most inexpensive weed treatment option. As such, it is also the most important weed management action and should be the foundation for any weed management program (Nevada's Coordinated Invasive Weed Strategy).

PROCESS OF INVASION
Introduction **+ E**stablishment **+R**eproduction **= SPREAD**

For effective weed prevention, it is important to understand the characteristics of weed species and the ecology of the system that enable them to establish and spread. A characteristic of many invasive weeds is that they readily invade disturbed sites, but do not venture readily into healthy native plant communities. However, some may establish and displace native communities. The process of invasion is introduction, establishment, reproduction and then spread. Some weeds specialize in colonizing disturbed areas. These species generally have specific physical traits that enable them to disperse and grow more rapidly in disturbed areas than other plants. This advantage allows the weeds to out-compete native plants during the initial colonization. Of course, avoiding disturbance altogether is the best defense against potential weed infestations, but often disturbance is inevitable, especially in the Wash where flooding occurs periodically. An effective mechanism to counter initial weed establishment is to seed or revegetate disturbed areas as soon as possible after the disturbance so that desirable plants may occupy the vacant ground before weeds establish. Secondly, weeds tend to invade plant communities that have been degraded by poor land management practices. By maintaining healthy plant communities, weeds are less likely to establish (Gershman & Lane). Revegetation must be a part of any weed management program.

Best Management Practices (BMPs)

IT IS IMPORTANT TO INSTILL IN OTHERS THAT NOXIOUS WEEDS ARE EVERYONE'S PROBLEM.

There are a variety of best management practices (BMP's) for weed prevention including awareness, early weed detection, limiting dispersal, minimizing disturbances, and establishment and maintaining native plant communities. Awareness is being informed and sharing that information with others. It is important to instill in others that weeds are everyone's problem. Frequent surveys of areas that have a high potential for infestations such as roads, disturbed areas, rights-of-way, and riparian corridors will enable weeds to be detected early. Reducing the spread of weeds is also an important part of prevention. Some preventive measures that can be used to reduce the likelihood of future weed infestations include limiting dispersal by properly disposing of seeds and reproductive plant parts; removing seeds embedded on clothing, animals and vehicles, and ensuring fill material (e.g., hay, straw and mulch) is weed free. Additional measures should be taken to inspect and clean vehicles prior to entering a weed free area and to clean vehicles before leaving a weed infested area. Actions should be taken to minimize disturbances by restricting travel through sensitive areas, encourage movement on established roads and trails, and avoid leaving exposed soil in construction areas. Seeding disturbed areas with perennial native species can be a valuable method for revegetation. Healthy plant communities can sometimes resist weed invasions proper weed management (Gershman & Lane).

As erosion control improvements are made in the Wash, large areas of land are cleared predominately with heavy equipment such as bulldozers. Disturbances also occur throughout the Wash due to illegal off-road vehicles and crews conducting fieldwork. BMPs should be implemented to reduce the introduction and spread of weeds in these areas during construction activities and off-road vehicle use.

BEST MANAGEMENT PRACTICES/CONSTRUCTION

- Restrict travel to established roads
- Be extra vigilant whenever gravel or fill material is brought in from elsewhere; weed seeds in this material can start new infestations, and bare soil provides an ideal environment for weed establishment.
- Avoid driving in noxious weed infested areas. Inspect vehicles for weed seeds stuck in tire tread or mud on the vehicles and prevent them from being carried to unaffected areas. Do not clean infested vehicles in weed free areas.
- Inspect maintenance and heavy equipment for weed seeds before it enters the property. Require that such equipment be cleaned first to remove weed seeds before being allowed entry. Clean equipment, especially mowers, which has been used in weed infested areas before moving it to another area.
- Avoid leaving piles of exposed soil in construction areas. Cover with plastic and revegetate with native species as soon as possible. If possible, spread material excavated during trail construction back on the trail instead of piling it on the side. (Gershman & Lane)

Cultural Controls

"Cultural methods of weed management are geared towards enhancing the desirable plant community to minimize weed invasions" (Sheley & Jacobs, 1999). The goal is to implement practices that make it more difficult for weeds to survive in a particular area (Johnson et al., 1999). Cultural controls are useful for large management projects. Techniques that favor native desirable species may include increasing plant competition, revegetation, fertilizing and flooding (Gershman & Lane).

Revegetation

Revegetation using native species may be the best, long-term alternative for controlling weeds where desirable species are under-represented. By establishing a healthy population of competitive grasses, re-invasion by some weeds can be avoided. One limitation of revegetation can be a lack of available seed from locally adapted native species, especially forbs and shrubs. Caution must be used as sometimes seed mixes may also be contaminated with weed seeds, making the revegetation counter productive (Gershman & Lane).

Figure 14. Cottonwood seedlings growing in a flood irrigation cell at Bosque del Apache.

Irrigation, Fertilization and Shading

Flood irrigating is another effective cultural weed control method. This technique has been used at the Bosque Del Apache National Wildlife Refuge (Figure 14) in New Mexico to encourage cottonwood seedlings to out-compete tamarisk. Timing is crucial for this technique to encourage the germination of the cottonwood seeds.

Additionally, properly timed application of fertilizers may help increase desirable plant species at a particular site, enabling them to encroach upon unwanted weeds (Sheley & Jacobs). Mulching may also help to reduce

weeds, serving as a physical barrier and revegetating light from reaching the undesirable seeds. Shading is another technique. Planting desirable plants close together can deprive the sunlight from the emerging weeds. Administering dye or fertilizers can cause an algae bloom, which creates a screen for the weeds. Although there are a variety of cultural tools that are effective for weed control, cultural control is generally most effective as part of an IWM program (Johnson et al).

Mechanical Controls

There are a variety of physical and mechanical means for weed management. These include pulling, hoeing, mowing and cutting, tilling, prescribed burning, and mulching. Physical methods are often effective on small infestations. Each method has benefits, drawbacks and optimal conditions (Gershman & Lane).

Hand Pulling, Hoeing, & Tilling

Hand pulling and hoeing are most effective where the complete crowns can be removed (Figure 15). When the soil is loose or moist, shallow rooted weeds can be pulled more easily (Gershman & Lane). Hand pulling can be effective in removing even deep-rooted rhizomatous weeds, but requires repeated, diligent treatment and is appropriate only for small infestations. Tilling the soil is most appropriate for level sites and when performed in conjunction with an active revegetation program. Tillage has been successful against some species, including Canada thistle (*Cirsium arvense*) where tilling the soil every 21 days effectively controls the weed. Although, some rhizomatous species such as leafy spurge spread readily when tilling is used (Sheley & Jacobs).

Tilling can be useful prior to planting because it may reduce the number of weed seeds in the soil that germinate. Tilling can place the seeds deeper in the soil where they cannot germinate. If done on a regular basis beginning prior to planting, the weed seed bank can be progressively reduced. This method is not appropriate for natural areas, as tilling greatly disturbs the soil and may severely disrupt natural plant communities and encourage the spread of weed seed.

Figure 15. Before and after picture of tall whitetop among cottonwood in nursery cell. Hand pulling is the selected control method at this site.

Mowing and Cutting

Mowing reduces seed production in some plants, especially annuals. However, caution should be used here as mowing or cutting can stimulate organization of some plants. Stage of growth and weather following the mowing event are critical considerations when counter-planting this technique. Plants mowed during the late bud or flower stages often produce fewer seeds than those mowed later in the season. If soil moisture is sufficient, some species increase the number of seeds produced after mowing. Repeated mowing in late-bud and early flower stages and again in the fall minimizes seed production of spotted knapweed (Sheley & Jacobs). Another note about mowing is that some species, (e.g. silver leaf nightshade and *Centaurea*) if mowed with flowers in bloom will continue to produce seed after cutting. In that case, it is important to remove all vegetative materials after mowing.

Example of a rototiller.

Mature infestations of tamarisk, root raking has become a proven and effective technique at the Bosque Del Apache Refuge and has been implemented in the Wash as well. This technique is implemented by attaching a root rake to a bulldozer. The rake is moved through the soil six to twelve inches below the surface, severing the root crown from the roots. This technique greatly disturbs the soil and requires large equipment. However, it can be a very effective tool, with quick results with a high success rate. If conducted as part of the land preparation for erosion control improvements and associated revegetation program, it can be a viable alternative to herbicides in some instances.

Prescribed Burns

Prescribed burns alone have mixed results. Generally, a single, low intensity fire does not effectively control weeds because the fire does not reach temperatures high enough to kill the root crowns and seeds present in the soil (Sheley & Jacobs). Many weed species such as tamarisk and some knapweeds, increase cover and density after a fire. Fire may actually enhance weed species over native plants because of the disturbance factor and added soil nutrients. Combining prescribed burns with follow-up herbicide treatments has been proven to increase the efficacy of the herbicide treatment (Sheley & Roche, 1982). This method can pose logistical problems. In addition to a burn plan, Clark County requires prescribed burns permits from Department of Air Quality and the fire department.


Prescribed burn of cut tamarisk at the Wash on April 9, 2003.

Biological Controls

Biological control generally refers to the use of living organisms such as insects, fungi, pathogens, and nematodes that attack specific weed species (Sheley & Jacobs). For this technique to be effective three things are necessary. First, the insect or disease must affect only the weed requiring control; otherwise, it may spread to desirable species and may become a pest itself. Secondly, the insect must have few natural enemies that interfere with their activities (Johnson et al). The majority of the invasive weeds have been introduced into North America without natural enemies from their place of origin. Biological controls are most commonly taken from the weed's place of origin and introduced into the weed infestation (Sheley & Jacobs). Third, the control organism must be adapted to the introduced environment.

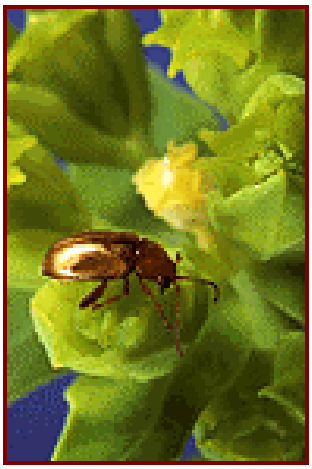

Figure 16. Flea beetle on a leafy spurge.

The goal with biological control is not to eradicate, but rather to control the infestation by reducing its abundance to acceptable levels (Wilson & McCaffrey, 1999). Results are mixed, whereas past bio-control efforts around the United States reveal that anywhere from zero to 90 percent of control can be expected (Wilson et al., 1998).

Biological control is most effective on large, dense infestations and in areas where infestations are in close proximity otherwise this method of control cost-prohibitive to treat. This technique reduces seed production or weakens plants and is most appropriate on weeds that are otherwise unmanageable. One advantage of biological controls is that they are self-perpetuating with the available food supply. Though initial costs may be high, the chances are minimal that the target species will not develop a resistance to the biological control (Wilson et al.).

Biological control does have drawbacks. Biological control organisms are available for very few weed species. This is because the cost of finding, collecting, screening and testing potential control organisms is very high. Usually biological control is not successful as the only weed management technique. It is important to keep in mind that the level of control varies and may take years to achieve. Additionally, maintaining a supply of control organisms requires maintaining the host weed species. Some of the more serious pitfalls of biological control include the inability to establish control organisms for reasons relating to environmental conditions that are not well understood (Gershman & Lane). Biologicals will cross boundaries. The two kinds of biological releases are insectary and control. Insectaries are established for the purpose of future collections and should contain a single type of insect. General releases are more effective if bugs are layered, that is with root crown feeders, stem feeders and seed head feeders.

Figure 17. Chinese leaf beetles are a biological control for tamarisk.

Numerous biological control programs have been conducted in Nevada for a variety of weed species including musk thistle, nodding thistle, spotted and diffuse knapweeds, leafy spurge, St. Johnswort, goat weed, dalmatian toadflax and tamarisk. The flea beetle, *Aphthona abdominalis,* is a beetle that is used to control leafy spurge which is a watch weed in Nevada as shown in Figure 16. For example, the Chinese leaf beetle, *Dtorhabda elongata* (Figure 17), has been released on tamarisk in Pershing, Churchill and Mineral Counties in Nevada (Wilson et al, 1998).

Another biological control agent is livestock. Livestock such as cattle, sheep and goats can be used to selectively graze/browse certain weeds in a specific area. This technique is appropriate for weeds that are nontoxic and palatable to the livestock used. The type of animal selected should be matched appropriately with the weed of interest (Gershman & Lane). This technique is used along ditches, fences, noncropland areas, forage crops and roadsides. The most common animals used are sheep and goats (Johnson et al). As a general rule, preference for grasses declines from horses to cattle to sheep to goats; goat and sheep are more likely to eat broadleaf weeds (forbs) than horses or cattle (Gershman & Lane). However, in order to achieve control using livestock, an infested area must be grazed several times during the growing season and for several successive years. Goats have been used in controlling Russian knapweed and tamarisk along the Muddy River in Clark County (Figure 18).

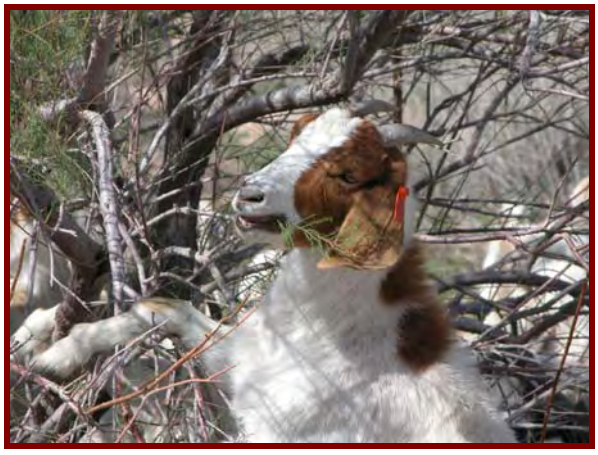

Figure 18. Goat grazing at the Muddy River, Nevada.

Special considertions must be made for livestock at weed management sites. The livestock need to be cared for daily and protected from predators. If the herd is enclosed in a fence it will need to be maintained. The herd must be closely observed to control the intensity and duration of the grazing to avoid overgrazing or avoid grazing impacts on desirable species. Additionally, the palatability of plant species may vary throughout the growing season. For example, cattle prefer young shoots of Canada thistle to the unpalatable mature stocks. Grazing or browsing should occur prior to seed set because weed seeds can be spread in manure and fur when animals are moved to another area. In addition, some weed species are toxic to certain grazing animals (Gershman & Lane).

Herbicides

Herbicides are chemicals that kill or injure plants. There are a variety of herbicides available for weed control. Herbicides may be organic or manufactured synthetically and are classified according to mode of action. Modes of action include growth regulators, amino acid inhibitors, grass meristem destroyers, cell membrane destroyers, root and shoot inhibitors and amino acid derivatives, which interfere with plant metabolism in a variety of ways. The selection of an herbicide should be based on the target weed species, the presence of desirable plant species, soil texture, depth and distance to water, and environmental conditions (Bussan & Dyer, 1999).

Figure 19. Herbicide tank sprayer.

Herbicide treatment may be an appropriate method for an eradication program, especially with the most invasive of weed species. This method is most effective on stands of single weed species with few non-target desirable plants present. Herbicides are also effective on small patches of weeds where other mechanical means are not effective or feasible. Weed species that are good candidates for this treatment include rhizomatous species that are unpalatable to livestock, weeds that require repeated pulling or cutting, and weeds located where treatment access is difficult. Additionally, herbicides can be used in conjunction with other methods (Gershman & Lane). The cut stump method with an herbicide application on the cambium layer is effective on such species as tamarisk.

Herbicides must be used according to the label. Proper care and application (Figure 19) must be taken to reduce the risk of herbicide moving beyond the target plant. Appropriate actions must be taken to avoid drift and unintended contact with the soil and water. Additionally, consideration must be given to some populations of weeds that may build a resistance to certain herbicides. Dr. Shane Snyder, SNWA Water Quality Research and Development Project Manager, has reviewed the toxicity and potential for accumulation of several herbicides that are effective on the three priority weed species in the Wash (tall whitetop, giant reed and tamarisk). The herbicides that were reviewed include: glyphosate, imazapyr, 2,4-D, chlorsulfuron, metsulfuron, and triclopyr. None of the herbicides have been shown to exhibit significant aquatic toxicity when used as directed, although some are not specifically labeled for aquatic use. With the possible exception of 2,4-D, these herbicides would not bioaccumulate to any measurable extent during use in the Wash. 2,4-D would not likely bioaccumulate to great extent and would depurate very quickly. See Appendix C for a complete discussion of these herbicides.

CHAPTER 7

INTEGRATED WEED MANAGEMENT

> IWM is "predicated on ecological principles and integrates multidisciplinary methodologies in developing ecosystem management strategies that are practical, economical and protective of public and environmental health" (Piper, 1991).

The most effective strategy for weed control often involves a combination of the described methods. Recall from the previous Section, "IWM is a strategy of selecting and implementing a combination of the weed control techniques or methods that collectively increase efficiency and effectiveness of treatment for a particular weed species and/or infestation with minimal adverse affects on non-target species" (Gershman & Lane). An example of an IWM strategy is the combination of mowing an established infestation with a follow-up herbicide treatment. The cut stump method with tamarisk is another type of IWM. Cutting the tamarisk alone may actually invigorate the basal sprouting. However, if an appropriate herbicide is applied to the cambium layer of the cut trunk immediately after cutting a higher mortality can be achieved. This method has been reported to have 80 to 85 percent kill rate of treated tamarisk in the Kern and Pixley NWRs (USFWS, 1996a).

When developing an IWM program, techniques should be selected and implemented that support the overall management goals and objectives for the area. Whereas traditional methods tend to simply treat the weed alone, IWM is designed to address the cause of the infestation. This increases success rates and focuses on long-term weed control versus short-term treatment of the symptoms. IWM is species-specific, tailored to exploit the weaknesses of a particular weed species. It is also site specific, designed to be a practical means for weed control with minimal risk to non-target organisms and their associated habitats (Gershman & Lane).

Guiding Principles

IWM programs are based on the biology and ecology of the target weed species and its surrounding habitat. By understanding the target weed species, control techniques can be selected that represent the most effective, efficient, environmentally sound and socially acceptable method for controlling particular plants (Brown et al., 1999).

Three guiding principles that should be used to develop an IWM plan:

1. Work to establish and maintain functioning native communities;
2. Implement appropriate prevention methods; and
3. Choose appropriate control actions.

Functioning Plant Communities

Keeping in mind that healthy plant communities may resist weed invasions, land use practices should be consistent with control. Restoration and revegetation activities can be used to manipulate the ecological functions of a system to strengthen existing communities, out-compete non-desirable plants, and mitigate disturbed areas. Recreational use and disturbance flood irrigation may degrade plant communities (Gershman & Lane).

Prevention

Weed prevention is also an important component of the IWM strategy. Techniques selected should specifically limit weed dispersal. Preventative measures to reduce soil disturbances or the introduction of weed seeds to an area, revegetating existing disturbed lands and practices that encourage desirable stands of perennial plants, are examples of techniques that work to prevent long-term weed establishment.

Appropriate Control Actions

Actions selected should be conducted at the most effective stage in a target species' lifecycle, such as when the plant is most vulnerable and the control actions are least damaging to non-target species, human health or the environment. Non-target species considerations may include sensitive species, native plant communities, wildlife, areas revegetated to control weeds, insect pollinators, insects that feed on target weeds species, and plant species that compete with the target weed species.

Herbicides should be selected based on their impact to the environment, and their effectiveness. All herbicides should be used in accordance with the label. Mechanical tools should be used properly as directed by the manufacturer. Consideration must be given to the timing of herbicide use and mechanical treatments to maximize effectiveness and reduce adverse affects. For example, improper timing of mowing may increase seed spread or unnecessarily disturb nesting species (Gershman & Lane).

IWM Strategies

The weed management actions selected for the IWM strategy should support the goals and objectives defined for the project area. The management actions should be tailored for the level of desired control. Generally, the levels of control are eradication, suppression or containment. Eradication is the most difficult level of control and requires the complete elimination of all plants and pieces of plants including rhizomes, seeds, roots etc. Suppression seeks to reduce the abundance of the weed species. Canopy cover or plant density usually measures this. Containment refers to confining an infestation, but not reducing the current infestation.

Some examples of actions that may be appropriate for large infestations include:

- Livestock grazing to weaken a plant species or reduce seed production,
- Re-seeding with highly competitive desirable plants that span the spectrum of growth periods (cool and warm season plants) and rooting depths (shallow and deep rooted),
- Biological agents to weakening plants and reducing seed production, and
- Herbicide applications

Examples of combinations of methods/techniques that have proven effective for particular weed species include: mowing or cutting plus herbicide for Canada thistle, tall whitetop, and spotted knapweed; cutting woody plants followed by an herbicide application for tamarisk; and herbicide

treatment plus re-seeding with competitive perennial grasses for Russian knapweed (Gershman & Lane).

In summary, IWM actions should reduce the need for weed control actions over the long-term. Actions should address the underlying causes of the infestation as well as the current weed infestation. Costs and benefits of any treatment should be factored into the decision. Actions that are relatively easy to implement and cost effective in the short- and long-term tend to be implemented and therefore seem to be more effective.

Current Wash Weed Management Actions

Various levels of weed management are currently underway in the Wash, focusing primarily on tall whitetop, tamarisk and giant reed. Additional species have been targeted at mitigation sites as well. With each species, a variety of strategies has been implemented according to the desired level of control. Several agencies are responsible for, and have conducted weed management, prior to the establishment of the boundary of influence by the Partnership. Vector Control is responsible for the area of the Wash from Vegas Valley to the Clark County Water Reclamation District. CCPCS maintains the Nature Preserve area within the Wetlands Park. The LVWCC is primarily responsible for mitigation sites along the Wash. The National Park Service, through a Memorandum of Agreement with the SNWA conducts various weed control activities throughout the Wash.

The Partnership was formed to facilitate the coordination among these agencies as well as integrate weed management activities and address weed issues inclusively in the boundary of influence. The following is a summary of the existing weed management activities.

Tall Whitetop Management Activities

TALL WHITETOP
Management goal
- Suppression

Management tactics
- Herbicide treatment
- Hand pulling
- Revegetation

The desired level of control for tall whitetop is suppression. As the Partnership's number one priority for management, an aggressive approach has been taken to address the tall whitetop infestation in the Wash. Research by Drs. Sue Donaldson and Wayne Johnson, from Nevada Cooperative Extension and information from other local and regional experts, has shown one of the most effective methods for control of tall whitetop is through herbicides. The Partnership's tall whitetop management program began in the fall of 2002 with a follow-up treatment in spring 2003. Based on recommendations from local and regional experts, herbicide treatments were conducted on the majority of the infestation. In conjunction with the treatment activities the Las Vegas Wash Project Coordination Team (LVWPCT) conducted water quality monitoring. Samples were collected before, during and after the treatments in the Wash to determine if herbicide was present in the water. The results were nondetect in the water samples. In select areas, hand pulling has been instituted and an intensive revegetation program is underway throughout the mitigation sites. Crews from the NPS EPMT conducted the treatment applications and mapped the infestations with GPS. The gross infested acres from the fall treatment are shown in Figure 9.

This program is expected to last three to five years for control of tall whitetop in the lower Wash. Controlling tall whitetop from the upstream sources in the Las Vegas Valley Watershed will likely reduce the seed source in the Wash, while protecting it from further infestation from this species.

Giant Reed Management Activities

GIANT REED
Management goal
- Eradication

Management tactics
- Herbicide treatment
- Cutting with herbicide treatment
- Prevention

There are 38 stands of giant reed that have been identified in the Wash, all of which have been mapped using GPS technology. The desired level of control for giant reed is eradication. Vector Control has treated the majority of stands of giant reed in the Wash using foliar herbicide treatment achieving nearly 100% mortality. The NPS will treat the remaining stands, including the Nature Preserve and Duck Creek as contracted in 2003. Cut stubble method or other appropriate methods may be selected for treatment. By removing this plant from the Wash system before it becomes established, we may catch the infestation before it can form dense stands as it did in southern California.

Tamarisk Management Activities

TAMARISK
Management goal
- containment

Management tactics
- cut stump
- root raking
- hand pulling
- revegetating

With roughly 1,500 acres of tamarisk in the Wash, the level of control targeted for tamarisk is containment, with suppression as the desired level of control within mitigation sites. The tamarisk infestation has been mapped using aerial photography. Large dense stands of tamarisk are removed in conjunction with the installation of grade control structures and bank stabilization features. The cut material is then stockpiled. Root raking has been implemented in conjunction with this method to prevent re-sprouting. A prescribed burn was conducted in April 2003 to reduce the slash pile from sixteen acres of cut tamarisk. The mitigation sites are heavily manicured for weeds, while sprouts are pulled during the growing season, and in areas with larger trees the cut stump method is employed. Additionally, an intensive revegetation program is in progress as part of the mitigation requirements for the COE 404 permit. Vector Control maintains the tributaries in unincorporated Clark County and the upper portion of the Wash through a combination of clearing with heavy equipment and herbicide treatments. CCPCS has removed approximately 40 acres of tamarisk from the Nature Preserve area using the techniques mentioned above.

As of January 2003, 43 acres of tamarisk have been cleared and revegetated with native species such as sandbar willows, Fremont cottonwoods and saltbush species. Heavy equipment is used to clear the tamarisk stands associated with erosion control improvements. The NDF Conservation Camps and Native Resources maintain the mitigation sites conducting weed management when necessary. Additionally, the NPS has been contracted to assist with the removal of tamarisk on the mitigation sites. The ultimate goal is to replace tamarisk with native species throughout the Wash. To help alleviate the hauling costs associated with disposing of cut and stockpiled tamarisk, the Wash Team and the Wetlands Park are pursuing the use of

prescribed burns to reduce the total material that would otherwise need to be hauled to the landfill.

Putting It All Together

Through the formation of the Partnership and continued interagency coordination, great strides have been made to address the weeds in the boundary of influence. Developing an IWM program for the Wash that incorporates the annual priorities will enable the Partnership to manage weeds for the long term and reach the goals for the area.

For each target species and/or infestation, a chart will be developed that incorporates the various integrated weed management techniques. Table 5 describes some of the techniques and effectiveness according to 'The War Against Tall Whitetop, FS-99-95.'

PRIORITIES

1. Create a strategy to address wildfire rehabilitation
2. Maintain less than 20% invasive species cover in restoration sites.
3. Treat and control existing stands of giant reed from the Las Vegas Wash and Clark County Wetlands Park over the next year, June 2003-May 2004.
4. Continue treatment and monitoring for significant control of tall whitetop in the Las Vegas Wash and Clark County Wetlands Park over the next year, June 2003- May 2004.
5. Suppress tamarisk associated with erosion control and bank stabilization improvements.
6. Identify desirable native plant species of the Colorado River Drainage.

GOALS

1. Contribute to the protection of the watershed
2. Promote native plant communities
3. Identify new noxious weed species invasions early
4. Improve the upland, riparian and wetland area along the Las Vegas Wash corridor
5. Complete a plant inventory of the Las Vegas Wash

TABLE 5. Tall Whitetop Control Methods - ('The War Against Tall Whitetop', FS-99-95)				
Control Method	Effectiveness	Frequency	Conditions	Limitations
Hand pulling	Limited	Ongoing	Moist loose soils; where herbicides are not appropriate	Labor intensive; Must remove 6 to 8 inches of root; Long-term control commitment
Livestock grazing/browsing	Limited	Ongoing	Effective for suppression during grazing	Goats and sheep prefer new growth; Long term implications unknown; May be poisonous to livestock
Biological controls				None available
Herbicide controls	Highly effective depending on herbicide	Spring and Fall treatment	During bud to early bloom stage; Foliar treatment	Timing is important; expensive
Flooding	Limited	Season-long flooding	Wetland, floodplain	Requires control of water levels
Mowing and herbicides	Limited	Multi-season	Dense, old infestations when herbicides alone have not been effective	Minimal effectiveness if soils are dry and plant re-sprouting is limited
Disking, mowing and herbicides	Limited	Multi-season	Dense, old infestations with large root systems present; stimulates germination of seeds within seed bank	Disturbs soil and native plants; intensive management that cannot be performed in many habitats; Spreads seed and plant parts

CHAPTER 8

MONITORING AND EVALUATION

Monitoring and evaluation is an essential component of long-term weed management. According to Elzinga et al. (1998), monitoring "…is the repeated collection and analysis of information to evaluate progress in meeting resource management objectives." To evaluate the effectiveness of weed control actions; observations of the treated areas need to be conducted and recorded on a regular basis. Additionally, management goals need to be clearly defined so that the control actions can be evaluated according to the monitoring results. Monitoring can help determine what is working and what is not, thereby saving time and resources. If the treatment program is not yielding the desired results, modifications should be made to the control program. Without a monitoring program, there would be no way to ascertain if the control program is achieving the management objectives (Gershman & Lane). Ensuring that control actions are effective is essential for developing and implementing a successful weed management program.

Developing a Monitoring Strategy

A monitoring strategy should be simple and straightforward. Complexity does not necessarily result in a better strategy (Gershman & Lane). The easier a program is to conduct, the more likely the monitoring program will be implemented. However, the level of effort invested in monitoring should be directly related to the desire for the control actions to be successful. For example, if the target weed is a high priority species and a high priority infestation, more effort should be levied to monitoring than to a low priority species and low priority infestation. Additionally, to avoid unintended effects, some treatment methods may inherently require more monitoring than others, such as instituting grazing or introducing a biological control.

Complexity does not necessarily mean a better strategy. The easier a program is to conduct, the more likely the monitoring program will be implemented

Monitoring is an ongoing process, not a short-term project. The data collected will become more useful with each additional year the monitoring is conducted. Trends will become apparent with increased repetitions. However, data can be skewed by external factors, such as weather, soils etc. Therefore, one of the limiting factors associated with any monitoring is establishing cause and effect relationships. The decline in the target weed population may result from unfavorable weather conditions that would have occurred regardless of the treatment method. To test the individual effectiveness of a treatment method, test plots can be established to compare treatment methods in as controlled a way as possible. The level of complexity required should be differentiated by the management goals and objectives (Gershman & Lane).

One of the limiting factors of monitoring is establishing cause and effect relationships.

Adaptive Management

As stated earlier, the monitoring program is an integral part of the control program. Based on the results of the effectiveness monitoring, the control program should be 'adapted' or revised if the goals and objectives are not being met through the control activities. The control program should be modified and improved based on the information gained through the monitoring

program. The steps of the adaptive management process are outlined in the chart below, Figure 20.

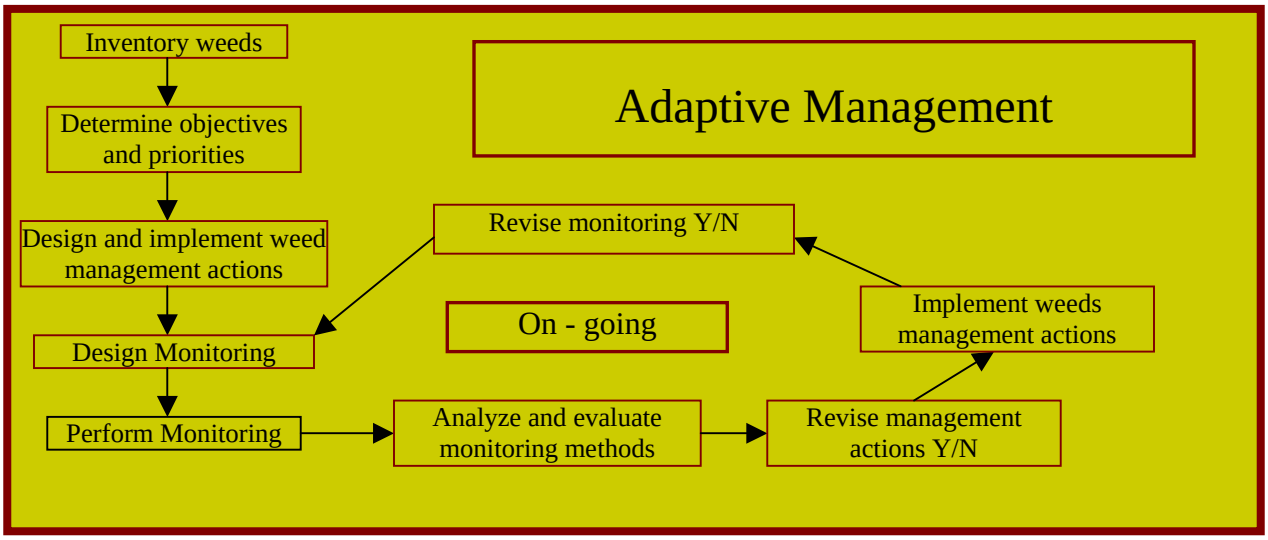

Figure 20. Steps in the Adaptive Management Process (Adapted from Gershman & Lane).

Setting Monitoring Priorities and Actions

Based on the weed management objectives established by the Partnership, monitoring actions will be developed for each objective. It is important that the weed management objectives specify time, numbers, location, as well as responsible party. Additionally, management actions can be modified if the weed management objectives are not being met.

The following is an example of weed management objectives, associated monitoring actions and management actions for a given weed species in the Wash. Management actions would be implemented if the weed management objectives were not being met.

> **Weed Management Objective:** Treat and control existing stands of giant reed in the Wash and Wetlands Park over the period, June 2003- May 2004.
> **Monitoring Action:** Visually inspect the giant reed stands the following growing season after treatment to determine success rates of treatment. Note the location of any remaining stands.
> **Management Action**: Schedule follow-up treatment.

CURRENT MONITORING PROGRAM

The Partnership has completed initial surveys of the Wash for giant reed, tamarisk and tall whitetop as described in the Weed Mapping section. These maps will be essential for tracking the distribution and size of infestations over time for priority weed species as well as documenting treatment method and established photo points. However, additional monitoring is necessary to determine the efficacy of the weed control treatments. A monitoring plan will be developed that incorporates the weed management objectives established by the Partnership for the purpose of evaluation of treatment effectiveness.

CHAPTER 9

COMMUNITY INVOLVEMENT AND PUBLIC AWARENESS

Key to Progress of LVWCC: Public Participation

The State of Nevada Noxious Weed Plan states "the rapid spread of invasive weeds in Nevada is directly related to the general public's lack of knowledge and awareness of both economic and ecological threats posed by invasive weeds."

Since the inception of the LVWCC in 1998, public participation has been key to its project's success. Located in an urban setting, the Wetlands Park and lower Wash is a community resource. Like many of the other challenges that face the stabilization and enhancement effort, invasive plants also require community involvement. According to the State of Nevada Noxious Weed Plan, "the rapid spread of invasive weeds in Nevada is directly related to the general public's lack of knowledge and awareness of both economic and ecological threats posed by invasive weeds"(page 15). To help improve the public's awareness of weeds, the Nevada Weed Action Committee (NWAC) has begun to develop a statewide Education Plan that will help coordinate and facilitate public outreach activities throughout the state. Additionally, many other groups with state, federal, local and environmental affiliations that promote weed education in Nevada. Many of these efforts are coordinated among a variety of states and throughout the world. It is important to complement the existing programs without duplicating efforts and take advantage of programs that are already in place through the LVWCC and Partnership members.

Children participating at the Green-up in the spring of 2003.

The Partnership will continue its existing weed public outreach efforts. Some of the Partnership accomplishments for highlighting the weeds in the Wash and the efforts of the Partnership itself include the development of Internet pages at *www.lvwash.org*, publishing news articles in a variety of newsletters, appearances on Channel 4's government television, conducting tours and presentations, and printed materials.

Public Outreach Plan

To enhance the effectiveness of the Partnership's activities and engage the community's support a public outreach strategy will be developed. The plan will work in tandem with existing outreach materials from state and local partners (without duplicating efforts) and identify areas that are not being addressed. Components of the plan will include items such as communication goals, objectives, strategy, target audiences, key message and tactics.

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CHAPTER 10

INTERAGENCY COORDINATION

The Partnership was initiated to collectively address the growing weed problem in the Wash. As the lead agency for the LVWCC, SNWA enlisted the support of the land managers and stakeholders for weeds in the Wash area. Each member entity was asked to support the collaborative effort and has voluntarily participated in the Partnership since its initiation, June in 2002. Each member has a different role and interest in the Partnership, and each has contributed greatly to the overall project in various capacities.

The following is a list of land managers and the area they are responsible for maintaining and is illustrated in Figure 21:

- Clark County Public Works-Vector Control – Tributaries in unincorporated Clark County including the upper portion of the Las Vegas Wash
- Clark County Parks and Community Services – Nature Preserve/Clark County Wetlands Park
- Clark County Water Reclamation District – property along Las Vegas Wash
- City of Henderson - property along Las Vegas Wash
- City of Las Vegas - property along Las Vegas Wash
- City of North Las Vegas - property along Las Vegas Wash
- Southern Nevada Water Authority – Las Vegas Wash
- Lake Las Vegas Resort – the lake and mitigation wetland at Lake Las Vegas
- National Park Service – Las Vegas Wash below Lake Las Vegas, Lake Mead and other sites along the Lower Colorado River
- US Bureau of Reclamation, property along Las Vegas Wash – Colorado River

Entities that do not have land management duties but participate in an advisory role for the Partnership include:

- University of Nevada Cooperative Extension
- Nevada Department of Agriculture
- USDA Natural Resources Conservation Service
- US Fish and Wildlife Service

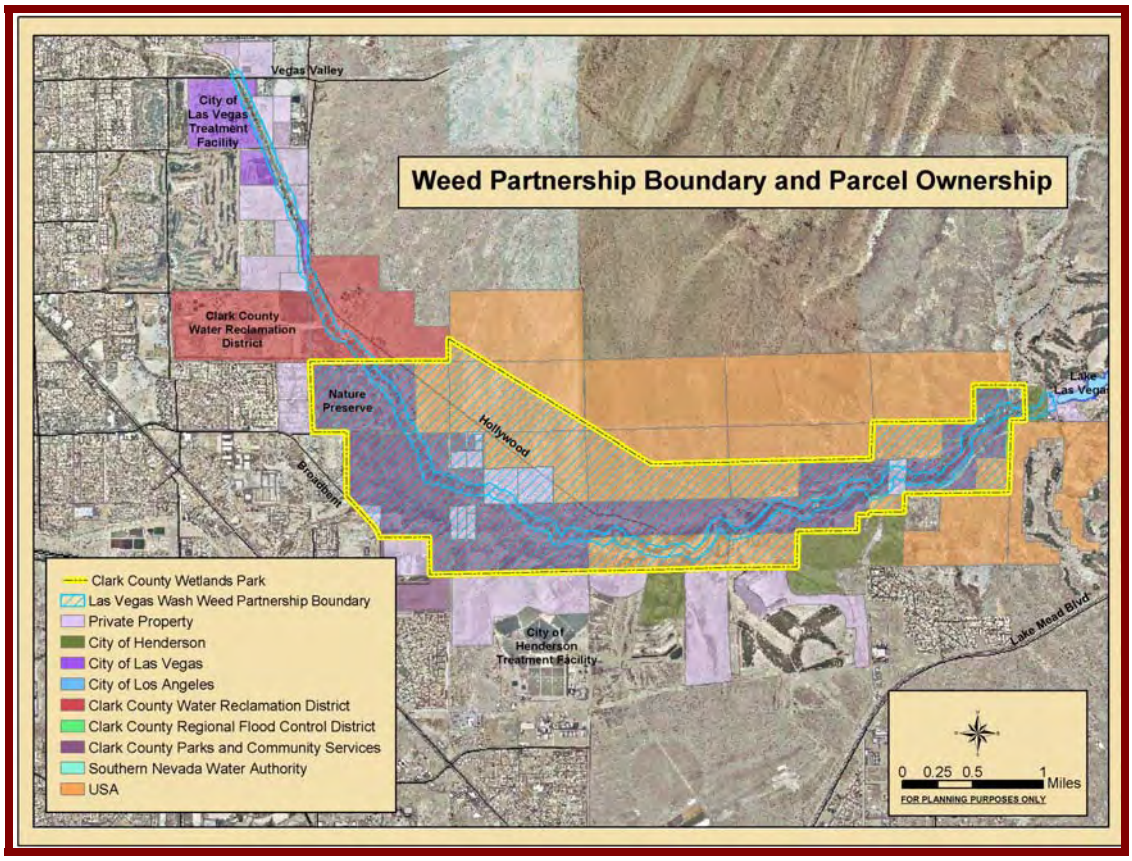

Figure 21. Weed boundary and parcel ownership for the Las Vegas Wash.

RESOURCES AND FUNDING

Funding for weed management in the Wash remains a significant issue for the LVWCC. The following section discusses Partnership resource sharing, funding arrangements and grant activities that have been implemented to augment existing funding.

Partnership Resources

To accomplish the mission of the Partnership, additional resources have been sought to support the long-term weed control program. In addition to providing support for funding programs and technical expertise, several agencies provided resources that helped make the weed control program possible. Vector Control treated giant reed and tall whitetop in the Wash in fall 2001 and continues to treat the Wash from Vegas Valley to the Clark County Water Reclamation District Access Road. Vector Control also provides equipment and herbicide storage areas, cleaning stations, as well as supplemental herbicide. Similarly, through funding received in February 2002 from the CC-MSHCP and the Conservation Fund, the NPS conducted trial treatments on tall whitetop in the Wash in spring 2002. Additionally, through a Memorandum of Agreement with the SNWA dated October 17, 2002, the NPS conducts weed control treatments and mapping in the Wash. The NPS supplies equipment, materials, and labor to support the weed management effort. The US Bureau of Reclamation supplies herbicide for the management activities. The Wash Team provides meeting support, coordination of activities in the Wash, and financial administration for the Partnership in addition to funding.

The following chart depicts the resources available by the Partnership agencies as well as related groups that may be enlisted for support that were identified at the time of printing. There may be additional entities and/or resources that may be identified and pursued in the future.

TABLE 6. RESOURCES AND AGENCIES

Stakeholder	Equipment	Workforce	Funding	Notes
Clark County Public Works - Vector Control	3 spray rigs: 1000 gallon, 300 and 100 gallon	4 full time employees for weed and insect control		
Clark County Parks and Community Services	Several back pack and hand sprayers	2 full time employees for weed control and wetland park maintenance		
National Park Service		6 employees in restoration and control		SNRT multi-agency federal program, weed survey
US Bureau of Reclamation	Track hoes, boats, GPS units, ATVs when available, helicopter, root plow	Crews from Provo and Yuma	Potential Funding source	Activities must fall within Bureau's missions, such as controlling erosion, protecting threatened and endangered species. Programmatic EIS
City of Henderson Parks and Recreation	Several spray rigs, boats	Employees		
University of Nevada Cooperative Extension	GPS units			Education, outreach, research
Nevada Department of Agriculture		Compliance inspectors on pesticide use		Education, NAC Chapter 555 enforcement, can obtain private property access
Nevada Division of Forestry		Work and fire crews		
Northern Arizona Conservation Corps		Contract labor with supervisor		
USDA Natural Resources Conservation Service	Weed mapping	Technical services and advice		WIN-PST pesticide use screening tool evaluates environmental risk
University of Nevada Reno, BRRC	GIS lab			
USDI Bureau of Land Management	Mapping		Potential Funding Source	

Stakeholder	Equipment	Workforce	Funding	Notes
Southern Nevada Water Authority	Mapping	Volunteers, NDF Conservation Camps, Native Resources	Grant	Ongoing revegetation at grade control structures in the Wash
US Fish and Wildlife Service		Botanist and contaminant specialist		Technical advice, help writing management plan for weeds
Outside Las Vegas			Potential funding source	
MSHCP			Potential funding source	

Grant Funding

As with many natural resource projects, grants provide much needed funding to reach resource goals. One of the recommendations of the LVWCC Funding Study Team during the development of the CAMP was to identify as many grant sources as possible to help supplement the existing funding for activities in the Wash. The Wash Team has been very aggressive in its pursuit of grant funding through a variety of sources. To date, the Wash Team has secured more than $500,000 in grant money and has more than $5 million in applications pending approval to support all Wash improvement activities including channel stabilization, habitat enhancement, biological and water quality studies, and public outreach. The following briefly describes the various funding proposals and awards that supported a weed management component in the Wash with brief descriptions of the grants and associated responsibilities.

- *National Fish and Wildlife Foundation*. The Wash Team was awarded $60,000 from the *Pulling Together Initiative* for weed management activities in the Wash and has applied for a renewal of this funding for the 2003/2004 fiscal year. Focused on developing long-term collaborative structures for weed management, this program is renewable for up to three years.

- *Southern Nevada Public Lands Management Act*. The Funding Study Team identified this as a potential funding source for the Wash, and there is currently an application for $2 million pending from the Parks, Trails and Natural Areas program under this legislation. Funding under this program will go, in part, to support weed abatement.

- *CC-MSHCP*. In August 2002, the Implementation and Monitoring Committee of the MSHCP allocated $24,000 in emergency funding to address tall whitetop in the Wash. The Weed Partnership has applied for $396,000 in funding to support weed abatement during the 2002-2004 biennium.

Addressing the expansive problems with invasive species in the Wash is neither an easy nor an inexpensive endeavor. Moreover, inaction increases not only the extent of the problem, but also the expense. To meet these demands, it is important to continually search for alternative sources of funding for weed management, and to ensure that it becomes a regular component of restoration activities in the Wash. As part of the planning process for the Wash, it is important to

regularly consider how staff and resources from various agencies and partners can be pooled. By utilizing existing staff and resources wherever possible, and augmenting these resources with grant funding, significant progress can be made to address the problem of invasive species in the Wash.

THE NEXT STEP

The Partnership has accomplished a great deal over the last year, including the identification and documentation of priority and watch weeds, development of goals and objectives, facilitation of various outreach activities, implementation of the weed control program for tall whitetop, and the development of an Integrated Weed Management Plan.

The next steps for the Partnership is to continue the implementation of the strategies defined in the management plan and continue facilitating the interagency coordination that has made this Partnership so successful. The Partnership will move from the planning phases to implementation of the items outlined in the Plan. Some of the major actions that will be undertaken are the development, and implementation of a monitoring plan, a public outreach program and pursuit of additional funding.

Sunrise in the Wash, 2003.

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Appendix A

Plant Species in Las Vegas Wash as of October 2002

Plant Species in the Las Vegas Wash as of October 2002

** – plants collected during June, 2002 * - *exotic plants* *life forms are relative to the regional climate*

Common Name	Scientific Name	Life Form
Pteridophytes		
Mosquito Fern Family	AZOLLACEAE	
Mosquito fern**	*Azolla sp.*	aquatic, riparian obligate
Gymnosperms		
Joint-Fir Family	EPHEDRACEAE	
Torrey joint-fir	*Ephedra torreyana*	shrub, terrestrial obligate
Dicots		
Amaranth Family	AMARANTHACEAE	
Tumbleweed**	*Amaranthus albus*	annual, terrestrial facultative
Honey sweet	*Tidestromia oblongifolia*	perennial, terrestrial obligate
Aster Family	ASTERACEAE	
Burro bush	*Ambrosia dumosa*	shrub, terrestrial obligate
Alkali aster**	*Aster subulatus var. ligulatus*	annual or biennial, riparian facultative
Emory waterweed	*Baccharis emoryi*	shrub, riparian facultative
Horseweed	*Conyza canadensis*	annual, riparian facultative
Horseweed**	*Conyza coulteri*	annual, riparian facultative
Brass buttons	*Cotula coronopifolia**	perennial, riparian obligate
False daisy**	*Eclipta prostrata**	annual or biennial, riparian obligate
Cudweed	*Gnaphalium luteo-album**	annual, riparian facultative
Sunflower	*Helianthus annuus*	annual, riparian facultative
Camphorweed	*Heterotheca cf. psammophila*	annual, terrestrial facultative
Prickly lettuce	*Lactuca serriola**	annual, riparian facultative
Salt marsh fleabane**	*Pluchea odorata*	annual, riparian facultative
Prickly sow thistle	*Sonchus asper*	annual, riparian facultative
Arrow weed**	*Pluchea sericea*	annual, riparian facultative
Sow thistle	*Sonchus oleraceus*	annual, riparian facultative
Wire lettuce	*Stephanomeria pauciflora var. pauciflora*	subshrub, terrestrial obligate
Cocklebur	*Xanthium strumarium*	annual, riparian facultative
Catalpa Family	BIGNONIACEAE	
Desert willow	*Chilopsis linearis ssp. arcuata*	tree, terrestrial facultative
Borage Family	BORAGINACEAE	
Salt heliotrope**	*Heliotropium curassivicum*	perennial, riparian facultative

Common Name	Scientific Name	Life Form
Mustard Family	BRASSICACEAE	
Desert alyssum	*Lepidium fremontii var. fremontii*	subshrub, terrestrial facultative
Tall whitetop**	*Lepidium latifolium*	perennial, riparian obligate
Water Cress	*Rorippa nasturium-aquatica*	aquatic perennial, riparian obligate
London rocket	*Sisymbrium irio**	annual, facultative terrestrial
Cactus Family	CACTACEACE	
Golden cholla	*Cylindropuntia echinocarpa*	succulent shrub, terrestrial obligate
Goosefoot Family	CHENOPODIACEAE	
Quail bush	*Atriplex lentiformis var. lentiformis**	shrub, riparian facultative
Allscale	*Atriplex polycarpa*	shrub, terrestrial facultative
Shadscale	*Atriplex confertifolia*	shrub, terrestrial obligate
Four-wing saltbush	*Atriplex canescens ssp. canescens*	shrub, terrestrial facultative
Bassia	*Bassia hyssopifolia**	annual, riparian facultative
Mexican tea**	*Chenopodium ambrosioides**	annual, riparian facultative
Lamb's quarters**	*Chenopodium album**	annual, riparian facultative
Summer cypress	*Kochia scoparia**	annual, riparian facultative
Russian thistle	*Salsola tragus**	annual, terrestrial facultative
Bush seepweed	*Suaeda moquinii*	shrub, terrestrial facultative
Legume Family	FABACEAE	
Catclaw	*Acacia greggii*	shrub/tree terrestrial facultative
Sour clover	*Melilotus indica*	annual, riparian facultative
Honey mesquite	*Prosopis glandulosa var. torreyana*	tree, terrestrial facultative
Screw-bean mesquite	*Prosopis pubescens*	riparian tree, riparian obligate
Indigo Bush	*Psorothamnus fremontii var. fremontii*	shrub terrestrial obligate
Desert senna	*Senna armata*	shrub terrestrial obligate
Waterleaf Family	HYDROPHYLLACEAE	
Purple phacelia	*Phacelia crenulata var. crenulata*	annual, terrestrial obligate
Krameria Family	KRAMERIACEAE	
Range rhatany	*Krameria erecta*	subshrub, terrestrial obligate
Duckweed Family	LEMNACEAE	
Duckweed**	*Lemna sp. (ca. minor)*	aquatic perennial, riparian obligate
Loasa Family	LOASACEAE	
Stick-leaf	*Mentzelia sp. (ca. albicaulis)*	annual, terrestrial obligate
Mallow Family	MALVACEAE	
Desert mallow	*Sphaeralcea ambigua var. ambigua*	perennial, terrestrial obligate

Common Name	Scientific Name	Life Form
Plantain Family	PLANTAGINACEAE	
Common plantain**	*Plantago major**	perennial, facultative riparian
Buckwheat Family	POLYGONACEAE	
Rigid spineplant	*Chorizanthe rigida*	annual, terrestrial obligate
Buckwheat	*Eriogonum deflexum var. deflexum*	annual, terrestrial obligate
Desert trumpet	*Eriogonum inflatum var.s*	perennial, terrestrial obligate
Little trumpet	*Eriogonum trichopes*	annual, terrestrial obligate
Willow weed**	*Polygonum lapathifolium*	annual, riparian obligate
Dock**	*Rumex stenophyllus*	perennial, riparian obligate
Willow Family	SALICACEAE	
Fremont cottonwood	*Populus fremontii*	tree, riparian obligate
Narrow-leaved willow**	*Salix exigua*	shrub, riparian obligate
Gooding willow**	*Salix goodingii*	tree, riparian obligate
Red willow	*Salix laevigata*	tree, riparian obligate
Figwort Family	SCROPHULARIACEAE	
Water speedwell**	*Veronica anagallis-aquatica*	perennial, obligate riparian
Nightshade Family	SOLANACEAE	
Sacred datura	*Datura wrightii*	perennial, terrestrial facultative
Peachthorn	*Lycium andersonii var. andersonii*	shrub, terrestrial obligate
Tree tobacco	*Nicotiana glauca*	shrub, terrestrial facultative
Desert tobacco**	*Nicotiana obtusifolia*	perennial, terrestrial facultative
Black nightshade	*Solanum nigrum*	perennial, terrestrial facultative
Tamarisk Family	TAMARACACEAE	
Salt cedar	*Tamarix cf. parviflora**	exotic tree, riparian facultative
Salt cedar**	*Tamarix cf. ramosissima**	tree, riparian facultative
Caltrop Family	ZYGOPHYLLACEAE	
Creosote bush	*Larrea tridentata*	shrub, terrestrial obligate

Monocots

Sedge Family	CYPERACE	
Nut-sedge**	*Cyperus cf. esculentus*	emergent perennial, riparian obligate
Spike-rush	*Eleocharis cf. montevidensis*	emergent perennial, riparian obligate
Spike-rush**	*Eleocharis macrostachya*	emergent perennial, riparian

Common Name	Scientific Name	Life Form
		obligate
Tule	*Scirpus acutus var. occidentalis*	emergent perennial, riparian obligate
Olney three-square	*Scirpus americanus?*	emergent perennial, riparian obligate
California tule**	*Scirpus californicus*	emergent perennial, riparian obligate
Bulrush**	*Scirpus maritimus*	emergent perennial, riparian obligate
Common three-square**	*Scirpus cf. pungens*	emergent perennial, riparian obligate
Rush Family	JUNCACEAE	
Wire rush	*Juncus balticus**	emergent perennial, riparian obligate
Grass Family	POACEAE	
Bent grass**	*Agrostis viridis**	perennial, riparian obligate
Bermuda grass	*Cynodon dactylon**	perennial, riparian facultative
Saltgrass	*Distichlis spicata*	perennial, riparian obligate
Barnyard grass**	*Echinochloa crus-galli**	annual, riparian facultative
Mexican sprangletop**	*Leptochloa uninerva*	perennial, riparian obligate
Witchgrass**	*Panicum capillare*	annual, riparian facultative
Galleta grass	*Pleuraphis rigida*	perennial, terrestrial obligate
Rabbit's foot grass	*Polypogon monspelliensis**	exotic annual, riparian obligate
Common reed**	*Phragmites australis*	perennial, riparian obligate
Splitgrass	*Schismus barbatus**	annual, terrestrial obligate
Giant reed	*Arundo donax*	perennial, riparian obligate
Cattail Family	TYPHACACEAE	
Southern cattail	*Typha dominigensis*	emergent perennial, riparian obligate

Appendix B

Las Vegas Wash Coordination Committee Biological Monitoring Programs: Species Identified through September 2003

Las Vegas Wash Coordination Committee Biological Monitoring Programs: Species Identified through September 2003

Fish Survey

Green sunfish (*Lepomis cyanellus*)
Mosquitofish (*Gambusia affinis*)
Common carp (*Cyprinus carpio*)
Black bullhead (*Ameiurus melas*)
Red shiner (*Cyprinella lutrensis*)
Suckermouth catfish (Family Laricariidae: *Hypostomus plecostomus)*
Fathead minnow *(Pimephales promelas)*

Reptile Survey

Western whiptail lizard (*Cnemidophorus tigris*)
Desert horned lizard (*Phyrnosoma platyrhinos*)
Western banded gecko (*Coleonyx variegatus*)
Desert common night lizard (*Xantusia vigilis*)
Desert spiny lizard (*Sceloporus magister*)
Long-nosed leopard lizard (*Gambelia wislizenii*)
Desert iguana (*Dipsosaurus dorsalis*)
Side-blotched lizard (*Uta stansburiana*)
Zebratail lizard (*Callisaurus draconoides*)
Great basin gopher snake (*Pituophis melanoleucus*)
Western blind snake (*Leptotyphlops humilis*)
Common kingsnake (*Lampropeltis getulus*)
Sidewinder (*Crotalus cerastes)*
Red coachwip (*Masticophis flagellum*)
Great Basin Collared Lizard (*Crotophytus bicinctores*)

Small Mammal Survey

Long-tailed pocket mouse (*Chaetodipus formosus*)
Desert pocket mouse (*Chaetodipus penicillatus*)
Little pocket mouse (*Perognathus longimembris*)
Cactus mouse (*Peromyscus eremicus*)
Merriam's kangaroo rat (*Dipodomys merriami*)
Desert woodrat (*Neotoma lepida*)
House mouse (*Mus musculus*)
White-tailed antelope squirrel (*Ammospermophilus leucurus*)
Desert shrew *(Notiosorex crawfordi)*
Round-tailed ground squirrel *(Spermophilus tereticaudus)*

Bird Census

GREBES	Pied-billed Grebe
	Eared Grebe
	Western Grebe
	Clark's Grebe
CORMORANTS	Double-crested Cormorant
BITTERNS & HERONS	Great Blue Heron
	Great Egret
	Snowy Egret
	Green Heron
	Black-crowned Night-Heron
IBISES	White-faced Ibis
NEW WORLD VULTURES	Turkey Vulture
WATERFOWL	Canada Goose
	Wood Duck
	Gadwall
	Mallard
	Cinnamon Teal
	Northern Pintail
	Green-winged Teal
	Common Goldeneye
	Common Merganser
HAWKS	Osprey
	Northern Harrier
	Sharp-shinned Hawk
	Cooper's Hawk
	Red-shouldered Hawk
	Red-tailed Hawk
FALCONS	American Kestrel
	Peregrine Falcon
	Prairie Falcon
NEW WORLD QUAIL	Gambel's Quail
RAILS, GALLINULES & COOTS	Virginia Rail
	Common Moorhen
	American Coot
PLOVERS	Killdeer
STILTS & AVOCETS	Black-necked Stilt

	American Avocet
SANDPIPERS & PHALAROPES	Greater Yellowlegs
	Lesser Yellowlegs
	Spotted Sandpiper
	Least Sandpiper
	Long-billed Dowitcher
	Common Snipe
GULLS & TERNS	Ring-billed Gull
DOVES	Rock Dove
	White-winged Dove
	Mourning Dove
ROADRUNNERS	Greater Roadrunner
TYPICAL OWLS	Northern Saw-whet Owl
SWIFTS	Vaux's Swift
	White-throated Swift
HUMMINGBIRDS	Black-chinned Hummingbird
	Anna's Hummingbird
	Broad-tailed Hummingbird
KINGFISHERS	Belted Kingfisher
WOODPECKERS	Northern Flicker
TYRANT FLYCATCHERS	Western Wood-Pewee
	Black Phoebe
	Say's Phoebe
	Ash-throated Flycatcher
	Cassin's Kingbird
	Western Kingbird
SHRIKES	Loggerhead Shrike
VIREOS	Warbling Vireo
CROWS & JAYS	Western Scrub-Jay
	Pinyon Jay
	Common Raven
SWALLOWS	Tree Swallow
	Violet-green Swallow
	Northern Rough-winged Swallow
	Bank Swallow
	Cliff Swallow

	Barn Swallow
VERDINS	Verdin
BUSHTITS	Bushtit
WRENS	Rock Wren Marsh Wren Bewick's Wren
KINGLETS	Golden-crowned Kinglet Ruby-crowned Kinglet
GNATCATCHERS	Blue-gray Gnatcatcher Black-tailed Gnatcatcher
THRUSHES	Hermit Thrush American Robin
MOCKINGBIRDS & THRASHERS	Northern Mockingbird Crissal Thrasher
STARLINGS	European Starling
PIPITS	American Pipit
WAXWINGS	Cedar Waxwing
SILKY FLYCATCHERS	Phainopepla
WOOD-WARBLERS	Orange-crowned Warbler Lucy’s Warbler Yellow Warbler Yellow-rumped Warbler Palm Warbler MacGillivray’s Warbler Common Yellowthroat Wilson's Warbler Yellow-breasted Chat
TANAGERS	Western Tanager
EMBERIZIDS	Spotted Towhee Abert's Towhee Chipping Sparrow Brewer's Sparrow Vesper Sparrow Lark Sparrow Black-throated Sparrow Savannah Sparrow

	Fox Sparrow
	Song Sparrow
	Lincoln's Sparrow
	White-crowned Sparrow
	Dark-eyed Junco
CARDINALS, GROSBEAKS & BUNTINGS	Black-headed Grosbeak
	Blue Grosbeak
	Lazuli Bunting
	Indigo Bunting
BLACKBIRDS	Red-winged Blackbird
	Western Meadowlark
	Yellow-headed Blackbird
	Brewer's Blackbird
	Great-tailed Grackle
	Brown-headed Cowbird
	Bullock’s Oriole
FINCHES	House Finch
	Lesser Goldfinch
OLD WORLD SPARROWS	House Sparrow

Appendix C

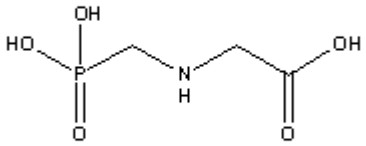
Review of Toxicity and Accumulation Data for Common Herbicides

Review of Toxicity and Accumulation Data for Common Herbicides

Dr. Shane Snyder, SNWA WQR&D Project Manager
October 2002

The LV Wash Team is currently working to rid the LV Wash area of invasive species of plants such as tall whitetop, giant reed, and tamarisk. In order to effectively remove and kill these plants, herbicides are generally used. USF&W has requested that SNWA investigate the toxicity of any herbicides used along the wash in order to protect animal species, especially the endangered razorback sucker. Furthermore, USF&W has requested that fish tissues from the LV Wash and Bay be analyzed for any herbicides used in the wash. The primary herbicides that may be used in the LV Wash are Rodeo™ (glyphosate), Arsenal™ (imazapyr), Weedar 64™ (2,4-D), chlorsulfuron, metsulfuron, and triclopyr. Each of these herbicides has high water solubility and low toxicity. At the application rates predicted for the LV Wash area, there is no expected toxicity or bioaccumulative potential to the aquatic wildlife in this area. The following data will show that a monitoring program for fish bioaccumulation is unnecessary due to physicochemical properties of these herbicides and the low rate of use.

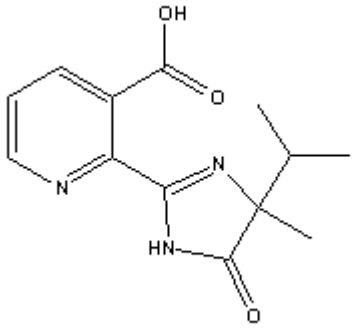
Glyphosate: (*N*-(phosphonomethyl)glycine):



Glyphosate is a broad-spectrum herbicide used to control grasses, sedges, and broad-leaved weeds. It is extremely water soluble (10,000 mg/L at 25° C) [1]. Glyphosate is practically nontoxic by ingestion with a reported oral LD50 of 5600 mg/kg in rats. Oral LD50s are greater than 10,000 mg/kg in mice, rabbits, and goats. In chronic studies up to 2 years, no effects were observed in rats, dogs, mice, and rabbits [2]. In acute toxicity studies using goldfish and rainbow trout, glyphosate was not found to be toxic at levels commonly used for weed control [3]. Glyphosate is practically nontoxic to fish with a 96-hour LC50 of 120 mg/L in sunfish, 168 mg/L in harlequin, and 86 mg/L in rainbow trout. The NOEC levels reported in fish during acute toxicity studies were always greater than 48 mg/L and generally above 100 mg/L. A 255 day chronic study using fathead minnows indicated a maximum acceptable toxicant concentration (MATC) of >25.7 mg/L. In other aquatic species, the 96-hour LC50s were 934 mg/L in crabs and 281 mg/L in shrimp. The 48-hour LC50 in Daphnia is 780 mg/L [1]. There is a very low potential for the compound to build up in the tissues of aquatic organisms because of the high water solubility. Furthermore, glyphosate binds tightly to soils and does not leach appreciably, and has a low potential for runoff. One estimate indicated that less than 2% of the applied chemical is lost to runoff. The $t_{1/2}$ for soil degradation is approximately 60 days [1]. Bioconcentration factors (BCFs) have been determined for crustaceans, mollusks, and fishes [1]. In fish, 10 – 14 day studies indicated BCFs from 0.03 – 0.18, which are extremely low. For mollusks, 28 – 35 day studies indicated BCFs from 4.8 – 9.6, again, these are very low. A 28 day exposure for crustaceans determined BCFs from 8 – 9. These BCFs are all less than 10 and less than 1 for fish indicate NO potential for bioaccumulation. Using the highest BCF reported for fish (0.26) and assuming an analytical method detection limit of 10 ug/kg fish tissue, a one kg fish would have to be

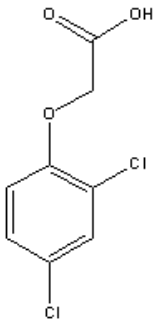
exposed to 38 ug/L of glyphosate in water in order to even detect this herbicide. Furthermore, an analytical detection limit for glyphosate would likely be much greater than 10 ug/kg fish tissue. Likewise, a 1994 paper by Wang et al. found that glyphosate would not bioaccumulate [4]. Additionally, a review paper by Smith and Oehme in 1992 reported that glyphosate does not leach into nontarget areas, is nontoxic to mammals, birds, and fish, and showed no bioaccumulation in the food chain [5]. This paper went on to report that glyphosate biodegraded into natural products and when used correctly posed no threat to the environment and its inhabitants [5]. For these reasons, fish bioaccumulation studies for glyphosate in fish from the LV Wash where minute amounts of glyphosate are to be used would be a waste of time and public funds.

Imazapyr: (2-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl):



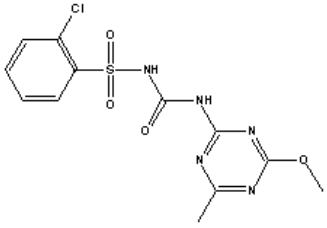
Imazapyr is a herbicide used to control annual and perennial grass and broad-leaved weeds, brush, vines, and many deciduous trees [6]. It is a member of the imidazolinone herbicide family and has an extremely high water solubility of 11,272 mg/L [2]. Imazapyr is not toxic to fish with an LC50 for bluegill sunfish >100 mg/L [2]. Although the adsorption of imazapyr in soils is generally considered weak, the $t_{1/2}$ for soils has been determined to range from 25 - 141 days depending on soil type [2]. In water, imazapyr is rapidly degraded by sunlight with an average $t_{1/2}$ of 2 days [7]. Imazapyr is of relatively low toxicity to birds and mammals with LD50s of >5000 mg/kg and >2150 mg/kg for rats and mallard ducks, respectively [2]. Miller et al. found that imazapyr is excreted rapidly in urine and feces and no detectable residues in body tissues [8]. In a bioconcentration study using bluegill sunfish, imazapyr was not found to accumulate and the BCF was found to be less than one [9]. Based on the structure of imazapyr, it would be difficult to detect in tissues at low concentrations (μg/kg). Furthermore, no analytical methods could be found for determination of imazapyr in biota as previous BCF studies were undertaken using radio labeled imazapyr [8]. Assuming an analytical method could be developed, detection limits in tissues would most likely be in the mg/kg range. Since the BCF of this compound is less than one and the detection limits would most likely be in mg/kg, water concentrations would have to exceed mg/L concentrations in order to detect this compound in fish tissues (assuming an analytical method could be developed).

2,4-D: (2,4-dichlorophenoxyacetic acid):



2,4-D is one of the oldest herbicides used in the US. It was developed during World War II and was a component of the famous Agent Orange used during the Vietnam War. 2,4-D remains one of the most widely used herbicides on the market. 2,4-D is a selective herbicide that kills dicots (but not grasses) by mimicking the growth hormone auxin [2]. Only the salt forms are used for aquatic applications as ester formations can be toxic to fish and invertebrates [2]. The water solubility of 2,4-D is high at 890 mg/L at 25° C. The fate of 2,4-D in the environment depends mainly on the pH since it is a carboxylic acid. At pHs above seven, 2,4-D is converted rapidly to the anion form which is susceptible to microbial and UV degradation [4,10]. Some formulations of 2,4-D are highly toxic to fish while others are less so. For example, the LC50 ranges between 1.0 and 100 mg/L in cutthroat trout, depending on the formulation used. Channel catfish had less than 10% mortality when exposed to 10 mg/L for 48 hours [11]. Green sunfish, when exposed to 110 mg/L for 41 hours, showed no effect on swimming response [11]. LC50 levels for bluegill sunfish and rainbow trout were 263 and 377 mg/L, respectively [2]. In a series of testing of various fish species, acute toxicity studies found LC50 values for 2,4-D ranging from 0.9 – 300 mg/L [1]. Limited studies indicate a half-life of less than 2 days in fish and oyster tissues [11]. The World Health Organization concluded that 2,4-D does not accumulate or persist in the environment with degradation mechanisms mainly of microbial and UV [12]. 2,4-D does not bind greatly to soils, therefore, it may enter water through run off or leaching [2]. Wang et al. found that 2,4-D did not readily degrade in natural waters with 80% of applied 2,4-D remaining in water after 56 days [13]. This report also showed that 2,4-D did exhibit minor bioaccumulation with a BCF of 18 for carp and tilapia [13]. 2,4-D has been detected in oysters and clams in concentrations up to 3.8 mg/kg [2]. Although 2,4-D can be mildly bioaccumulated, it does depurate rapidly [2]. Sufficient analytical methods exist to develop a monitoring program for 2,4-D in the environment. At the application rate expected for the LV Wash program, it would not be expected that detectable levels of 2,4-D would exist in fish tissues from this area. Since 2,4-D rapidly depurates and has a low BCF factor, the sporadic use and low application rates of 2,4-D around the LV Wash would not be expected to cause any environmental impact.

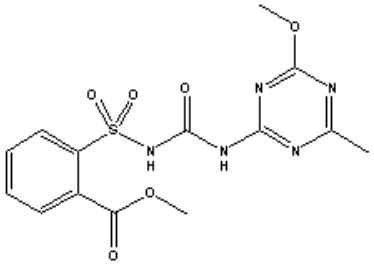
Chlorsulfuron: (2-chloro-N-[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)aminocarbonyl]-benzenesulfonamide)



Chlorsulfuron (CAS# 64902-72-3) is a member of the triazinylsulfonylurea family of herbicides. Chlorsulfuron is also known by the trade name of Telar®, which contains 75% chlorsulfuron and 25% inert ingredients [14]. Chlorsulfuron has also been marketed under the trade names Glean and DPX 4189 [15]. It is registered as a general use herbicide. Chlorsulfuron has high water solubility (31,800 mg/L [15]) and low volatility (vapor pressure 6.1 x10^{-6} mbar [1]) both measured at 25°C and pH 7.0. The half-life ($t_{1/2}$) of chlorsulfuron in dry soil is 6-8 days [1]. Hydrolysis occurs in the aquatic environment with a $t_{1/2}$ of 4-8 weeks at pH 5.7–7.0 at 20°C [16]. Chlorsulfuron is used mainly to control broadleaf weeds and some annual grass weeds. A typical

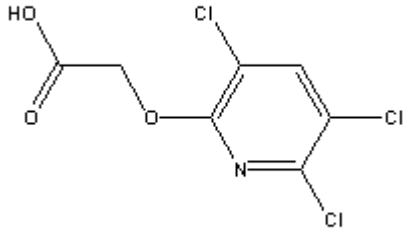
usage rate is 0.25 – 3.0 ounces of active ingredient per acre. Chlorsulfuron is practically nontoxic to fish and aquatic invertebrate animals and does not exhibit detectable bioaccumulation [14-16]. The 96 hour LC_{50} values for bluegill sunfish and rainbow trout were both >250 mg/L [1,14]. For mammals, the oral LD_{50} is 5550-6290 mg/kg body weight [1]. *Daphnia magna* 48-hour LC_{50} was determined to be 370 mg/L [16]. For both acute and subacute toxicities to bobwhite quail and mallard ducks, the LD_{50} and LC_{50}, respectively, were both greater than 5000 mg/kg. Chlorsulfuron residues can be measured by EPA method 632. Chlorsulfuron would not be expected to strongly bind to soils and has a K_{OC} of 33 [16]. From the data available, it is reasonable to deduct that chlorsulfuron is not toxic and nonbioaccumulative at the concentrations that would be used in the LV Wash area.

Metsulfuron methyl: (methyl 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)-amino]carbonyl]-amino]-sulfonyl]benzoate)



Metsulfuron (CAS# 74223-64-6) is a member of the triazinylsulfonylurea family of herbicides. It is also known by the trade names Ally®, Escort®, Brush-off®, Granstar®, and Gropper® [1]. Metsulfuron is used to control brush and certain unwanted woody plants, annual and perennial broadleaf weeds, and annual grassy weeds and is generally applied at 0.33-4.0 ounces of active ingredient per acre for non-cropland uses [17]. Typical formulations such as Escort® and Ally® contain 60% metsulfuron methyl and 40% inert ingredients [17]. Metsulfuron has high water solubility at 109 mg/L, low vapor pressure at 5.79 x 10^{-5} mm Hg, and very low potential for bioaccumulation with a log K_{ow} of –1.9 at pH 7 [1]. The $t_{1/2}$ for soil is 120-180 days, while in water it is 1-8 days [18]. Metsulfuron is practically nontoxic to fish with 96-hour LC_{50}'s for rainbow trout and bluegill sunfish > 150 mg/L. Likewise, avian toxicity is very low with an oral LD_{50} value of > 2510 mg/kg for mallard ducks and dietary LC_{50} values of > 5620 ppm for mallard ducks and bobwhite quail [19]. Additionally, metsulfuron has very low toxicity to freshwater invertebrates with *Daphnia magna* a 48-hour LC_{50} of > 150 mg/L and a 21-day life-cycle NOEL for survival and reproduction of > 150 mg/L [19]. This herbicide was also found to be nontoxic to bees with an LD_{50} of > 25 μg/bee [18]. In mammals, metsulfuron was found to have an acute oral LD_{50} value of > 5000 mg/kg for male and female rats [17]. In general, metsulfuron methyl has very low toxicity and little potential for bioaccumulation. It would not be expected to cause adverse ecological impacts when used properly in the LV Wash area.

Triclopyr: ([(3,5,6-trichloro-2-pyridinyl)oxy]acetic acid)



Triclopyr (CAS# 55335-06-3) is a general use pyridine herbicide that is commercially available as a triethylamine salt or butoxyethyl ester of the parent compound [20]. Triclopyr is used to control woody plants and broadleaf weeds and has over 70,000 pounds of use annually in the U.S. [20]. It is marketed primarily as Garlon 4® but other herbicides may contain triclopyr as well, including: Crossbow®, ET®, Grazon®, PathFinder®, Redeem®, Rely®, Turflon®, and Release Silvicultural® [1,21]. Garlon® 3A and Garlon® 4 contain 44.4 and 61.6% triclopyr, respectively [21]. A typical application rate would be 0.25 to 9 pounds acid equivalent per acre [21]. Triclopyr has a moderate-high water solubility of 440 mg/L and low volatility of 1.7×10^{-6} mbar, each measured at 25°C [1]. The K_{OW} of triclopyr is very low (0.205 at pH 7) indicating an extremely low tendency for bioaccumulation [22]. Triclopyr formulations can degrade in the environment to the parent compound (triclopyr) and degradation products through hydrolysis, photolysis, and microbial transformation [22]. In soil and water, the ester and amine salt formulations rapidly convert to the acid, which is then neutralized to a relatively nontoxic salt [20]. Photolysis is the primary breakdown process in water and has relatively high kinetics [20]. The $t_{1/2}$ is highly dependent of moisture and carbon content, therefore, the values can range from 30-90 days, but may be longer in arid climates [20]. The breakdown product, trichloropyridinol, may have longer $t_{1/2}$'s which can range from 8-279 days [20]. The toxicity of triclopyr depends on the formulation, however, all formulations are considered to have low toxicity to all organisms tested (i.e., birds, mammals, worms, bees, microorganisms, and fish) [1,20-22]. Acute toxicities (LC_{50}) for triclopyr and the butyl ethyl ester formulation to wild birds (mallard duck, bobwhite quail, and Japanese quail) ranged from 2935->10,000 ppm [22]. The LD_{50}'s for mammals (rat, guinea pig, and rabbit) ranged from 310-1515 mg/kg [22]. The LC_{50}'s of triclopyr to *Daphnia magna*, trout, and bluegill were 1140, 117, and 148 mg/L, respectively [21]. Triclopyr was very nontoxic to bees with an LD_{50} of > 60 μg/bee [21]. In general, triclopyr and its major formations have low toxicities and low environmental persistence. However, it can form degradation byproducts depending on environmental conditions. With low application rates and careful handling, triclopyr would not pose environmental threats to the LV Wash ecosystem.

Synopsis:

None of the referenced herbicides have significant aquatic toxicity when used as directed. With the possible exception of 2,4-D, these herbicides would not bioaccumulate to any measurable extent during use in the LV Wash. 2,4-D would not likely bioaccumulate to great extents and would depurate very quickly. Very few analytical methods are available to sensitively measure these herbicides in animal tissues. To establish a monitoring program for these herbicides in animal tissues, a method would need to be developed. This would be extremely costly and most likely result in a high detection limit. Considering the high water solubility and radiometric BCF data available, a tissue-monitoring program for these herbicides is impractical.

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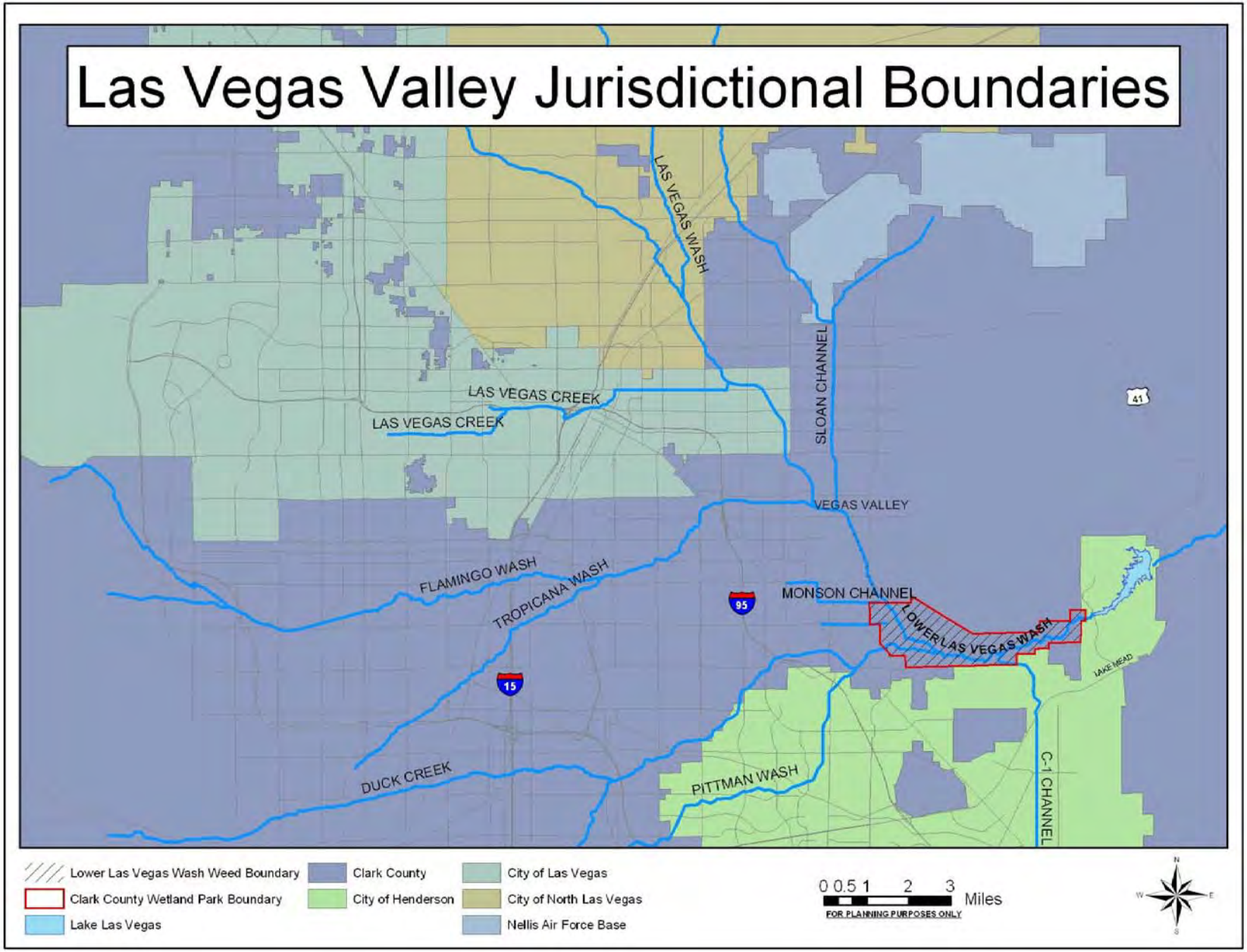
Appendix D

Las Vegas Wash Jurisdictional Boundaries


Las Vegas Valley Jurisdictional Boundaries
LAS VEGAS WASH
SLOAN CHANNEL
LAS VEGAS CREEK
LAS VEGAS CREEK
41
VEGAS VALLEY
FLAMINGO WASH
TROPICANA WASH
95
MONSON CHANNEL
LOWER LAS VEGAS WASH
LAKE MEAD
15
DUCK CREEK
PITTMAN WASH
C-1 CHANNEL
Lower Las Vegas Wash Weed Boundary
Clark County Wetland Park Boundary
Lake Las Vegas
Clark County
City of Henderson
City of Las Vegas
City of North Las Vegas
Nellis Air Force Base
0 0.5 1 2 3 Miles
FOR PLANNING PURPOSES ONLY
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